Proceedings of
THE CARIBOU WORKSHOP

Held Nov 24 - 26, 1988
in Williams Lake, B.C.

BC

Ministry of
Environment
WILDLIFE BRANCH

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Editor:

D. Hebert
Wildlife Branch
Ministry of Environment
Williams Lake, B.C

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CARIBOU WORKSHOP PARTICIPANTS

Enclosed is a partial summary of the caribou workshop held in Williams Lake during November, 1988.

The workshop addressed the main issues of habitat utilization and requirements, predation, inventory and research.

Caribou habitat and merchantable timber for logging are in direct conflict. The present management and planning systems are not capable of providing adequate solutions to this problem. The problem has been further compounded by the lack of population inventory and the need for a better understanding of the role of the wolf as a major limiting factor.

The workshop reports outline some of the inventory methods and procedures that are being used or tested and will eventually improve our population estimates. Similarly, the discussion surrounding habitat and predation limiting factors clearly demonstrated the potential and increasing impacts of wolf predation and the need for more detailed and intensive research.

Most importantly, it became evident that the conflict between caribou and mature timber requires that stratification of the caribou herds be done on a priority basis following the report of Stevenson and Hatler (1985).

Dr. D. Hebert
Head Wildlife Biologist
Cariboo, Northern Interior

TABLE OF CONTENTS

Preface

SOUTHEASTERN CARIBOU BIOLOGY

Caribou Diets and Arboreal Lichen Availability - *E. Rominger*. 1
Managing for Lichens in Second-growth Stands - *S. Stevenson*. 5
Caribou Biology of the Quesnel Highlands - *D. Seip*. 7
Habitat versus Predation as a Limiting Factor for Caribou - *T. Bergerud*. 10

INVENTORY AND POPULATION DYNAMICS

Summary of Information Presented on Day 2 - *I. Hatter*. 12
Population Parameters of Caribou in West Central B.C. - *D. Chichowski*. 26
How Imperfect is Caribou Inventory? - *R. Page*. 34
How Imperfect is Caribou Inventory?: A Response - *I. Hatter and D. Hatler*. 47

RESEARCH REQUIREMENTS AND DIRECTION

Research and Development Priorities for Caribou Management in British Columbia - *D.S. Eastman, R. Page, and G. Jones*. 54

APPENDIX 73

SUMMARY —
CARIBOU DIETS AND ARBOREAL LICHEN AVAILABILITY

E. Rominger, U.S. Fish & Wildlife Service. Nat. Ecology Research Centre, 1300 Blue Spruce Drive, Ft. Collins, Colorado, 80524

Rominger looked at the lichen biomass estimates of standing trees, blowdown/litterfall and effects of landform on tree density. He also deals with forage intake rates; primarily on Barren ground Caribou and Reindeer. Suggests 2 kg/day rather than 5 kg/day may be a more reasonable estimate. This is a more reasonable estimate when compared to dry forage and intake of other species. He cites Detrick (1984) as the most complete work, using the destructive technique of cutting branches, collecting all the lichen and weighing it. The literature available usually refers to subalpine fir and Engelmann spruce.

The main factor influencing the wide range of lichen density estimates has been stem density of the subalpine spruce/fir forests. Rominger's work has been extensive on stem density in mature and old-growth spruce/fir forests. These stem density estimates can be used to calculate lichen biomass estimates in glacial basins, ridgetops, mid-slopes and valley bottoms. Significant differences were found among physiographic types, with glacial basins supporting considerably more lichen biomass. Midslopes which make up most of the habitat in the mountainous ecosystems had considerably less lichen.

Lichen contributions through litterfall and windthrow ranged from 20 to 76 kg per hectare over 180 days in some areas which would be a substantial contribution to the forage base in early or late winter. (Minimum estimates were arrived at without using litterfall traps and herbivore removal prior to measurements may be as high as 47% (Stevenson 1978).

Whole tree lichen biomass estimates are important when considering the extensive use of windthrown trees during early winter by caribou. Lichen is available to caribou only on recently windthrown trees. Arboreal lichen deteriorates completely after lying under snow.

Combining the amount of lichen on individual trees, with the estimated stand density may allow estimation of litterfall ratios for various stands. Rominger found that during early winter, those caribou in high snowpack ecosystems (Selkirks), after snow accumulation was 20-30 cm, were searching the forest for litterfall or lichen that was within reach. Random plots indicated fresh thrown trees were dominated by subalpine fir (70-85%) and averaged 2.4 per hectare in the Selkirks (70% snag component). Comparing this with caribou locations, Rominger found an average of 7.5 freshly windthrown trees per hectare. He utilized this data from his whole tree lichen biomass estimate to suggest that windthrown subalpine fir trees could provide up to 9.3 kg/hectare of lichen at sites used by caribou during early winter verses 2.8 kg/hectare at random locations.

Data dealing with winter lichen intake rates generally utilize penned animals, Cs 137 fallout rates and esophogeal fistulated techniques. Rominger indicated that the forage based carrying capacity model work that is being done using 5 kg per day is probably high, and actual intake is probably substantially less than that reported for barren ground caribou (probably 2-3 kg/day).

Factors to be considered in regard to lichen intake rate of woodland caribou are the nutritional values, energy variation in foraging strategy, body size and winter severity. There is up to twice the protein in arboreal lichen as compared to terrestrial lichen. Foraging on arboreal lichen is probably more energy efficient than cratering of barren ground caribou. Milder (maritime) climates where caribou were not subjected to temperature extremes should also be considered. However, the larger body size of woodland caribou may cause an increase in intake rate compared to barren ground caribou.

EARLY WINTER HABITAT

Hypothetical example - Selkirk Mountains, B.C

1053 ha available early winter habitat at stem density of 300/ha (estimate) ABLA/PIEN - using moderate-high arboreal lichen biomass of ridgetops and 4:1 Abla-Pien ratio

246 g/Abla x 240 = 59 kg
110 g/Pien x 60 = 7 kg

66 kg x 0.13 kg = 9 kg/ha CAG between 2-6 m

9477 kg/lichen x 0.15 (2-3 m) = 1421 kg < 3 m height (max. foraging height during early winter)

2948 kg max. provided by blowdown (subalpine fir only = 80% of blowdown)

60 days on early winter range

---

5 kg/day intake rate
300 kg/caribou/early winter
5 caribou supported
10 additional caribou with blowdown

---

2 kg/day intake rate
120 kg/caribou/early winter
5 caribou supported
21 additional caribou with blowdown

LATE WINTER HABITAT

Ridgetops - example
400 trees/ha - for homogeneous old-growth stands of spruce-fir (U.S. Fish and Wildl. Serv. unpubl. data)

4:1 Abla:Pien ratio on ridgetops (Detrick 1984)
Lichen between 2 and 6 m (Detrick 1984)

246 g/Abla x 320 = 79 kg/ha
110 g/Pien x 80 = 9 kg/ha

88 kg/ha x 0.13 = 11 kg/ha (Current annual growth)
|
max. removal coefficient from Stevenson

Hypothetical example
8400 ha - available late winter habitat
92, 400 kg/lichen annually + (additional sources-litterfall/blowdown)
120 days on winter range

---

5 kg/day intake rate
600 kg/caribou - 60%
154 caribou supported ---> 60 caribou if low snowfall > 60% lichen biomass/branch in upper 2 m between 2 - 6 m

---

2 kg/day intake rate
240 kg/caribou - 60%
385 caribou supported---> = 150 caribou if low snowfall

Quesnel Highlands example
70,000 ha
770,000 kg food
- 856 caribou supported at 5 kg/day - 60% = 340 caribou with low snowfall
- 2139 caribou at 2 kg/day - 60% = 850 caribou with low snowfall

SUMMARY - MANAGING FOR LICHENS IN SECOND-GROWTH STANDS

Susan Stevenson

Silvifauna Research, 101 Burden Street, Prince George, B.C. V2M 2G8

This paper describes the opportunities to manage second-growth stands, to hasten their use as winter range by caribou and to encourage earlier and faster growth of arboreal lichens (particularly *Bryoria* and *Alectoria*). With improved second-growth, the expanded habitat can be managed so caribou are dispersed sparsely over large areas reducing the risks of predation and poaching. The ideas about stand management presented here are still at a development stage.

The establishment of lichens in young stands is limited by the distance from mature timber stands (dispersal is poor beyond 400 m from old stands), wind factors, suitable substrata (close needles and rough stable surfaces being ideal), and microclimatic conditions.

Lichens require light for photosynthesis and are metabolically active only when moist. Variation in temperature and moisture is therefore more beneficial than constant optimal conditions (especially to canopy lichen). Optimum lichen development in young stands is hampered before crown closure on exposed sites (by being too warm or dry) and after crown closure on mesic or wet sites (by being too shaded). Specific management practices, however, will allow lichen to become abundant in relatively young stands.

Partial cutting schemes (diameter limit logging) retain a moderate lichen biomass which allows propagules to colonize regenerating stands. The recovery of lichen biomass is faster in advanced regeneration than in clearcut areas planted with seedlings. One drawback is that larger areas must be under development at any one time if timber quotas are to be met, and that leads to increased roading and risk of poaching. Partial cutting should only be used if access control can be addressed.

Other ways to enhance lichen dispersal are: specifically planned cutblocks and retention of small old-growth patches. In 3- pass system, the size and configuration of cutblocks could be planned to keep a large proportion of the area within 350 m of mature timber over the first half of its reduction, permitting early establishment of lichens.

Retention of windfirm non-merchantable trees bearing abundant lichen biomass should be attempted whenever possible. Planning and cooperation between foresters and wildlife biologists are essential for these approaches to work.

Where the natural dispersal of lichen propagules in previously logged areas is not possible, inoculation with lichens should be considered. Inoculation technology involves spraying trees with an adhesive agent combined with chopped lichens. It is a promising method that has been used successfully on a limited basis. Manipulation of the microclimate will be necessary to enhance lichen development in some fully-stocked stands. Where lichen development would otherwise be limited by shade, a carefully -planned thinning program can maintain a more suitable microclimate.

At higher elevations, the snowpack controls lichen accessibility whereas at lower elevations, blowdown and litterfall become more important than standing trees. Litterfall and blowdown rates are somewhat lower in second-growth stands than old-growth stands. Thinning to improve lichen abundance in the young stands will dramatically reduce rates of litterfall, due to a reduction in the total number of stems and a reduction in the number of dead stems. There are two possible solutions:

1. Retain a residual stand during harvesting to ensure a source of litterfall and blowdown.

2. Use thinning techniques where standing dead trees (vs felled trees) are retained.

In conclusion, creation of second-growth stands that function as caribou winter range is critical for maintaining caribou populations. Attention must also be given to the problems of increased access and predation. The question of who will bear the cost of management programs must be addressed.

SUMMARY–CARIBOU BIOLOGY OF THE QUESNEL HIGHLANDS

D. Seip, Ministry of Forests, Vancouver Forest Region,
Forest Science Section, 4595 Canada Way, Burnaby V5G 4L9

Seip deals with the seasonal habitat use of the S.E. Woodland Caribou and the limiting factors affecting them. The early winter period of initial snow accumulation can cause some caribou to inhabit lower elevations (see habitat use table). Since Quesnel Lake is not rugged country, its gentle topography combined with less extreme snow conditions, allows the caribou to remain at higher elevations. In the Jan/Feb period the snow at higher elevations begins to firm up and provides better support for the caribou, allowing them to move up to higher elevations (1500-1800 m). In this period they are in closed canopy forests, mostly subalpine fir.

By March and April the snow becomes firm enough to allow the animals onto the higher open parkland habitat (1800 m). The best time to locate and census the caribou is during this time. If marked animals are used to locate the herds Seip believes approximately 85% of the total population can be located at higher elevations.

In May a substantial number of caribou move to lower elevations. However, there is a major variation between areas. While Revelstoke has approximately 95% of the caribou at lower elevations in May, Quesnel Lake has 40%, and Wells Gray Park only 25%. Seip sites predator avoidance as the reason for this high percentage remaining above snowline. Fecal nitrogen levels indicate the caribou are actually sacrificing food quality in doing so.

Calving in the first couple of weeks in June occurs at high elevations, again an anti-predator strategy. Summer habitat in the highland areas (i.e.,Quesnel Lake) tends to be in subalpine forest types often associated with sedge meadow (1600-1700 m). Consequently the caribou are summering with moose and wolves. In contrast, caribou in the more rugged mountainous areas (i.e.,Wells Gray Park) migrate up to thirty miles to summer in the alpine parkland (2000-2300 m).

Seip calculates the mortality rate of adult caribou (based on radioed caribou) at:

23% accidents

20% bear predation

32% wolf predation

7.5% poaching

Calf mortality in the first stages of the calf's life are probably due to: weak or defective calves, severe winter conditions, or late green-up. After the initial calving period, calf mortality was determined largely by the presence or lack of wolves. During four years of study in the highland habitat, no radio-collared caribou's calves survived to October when wolves were known to be in the area. The result has been an approximate 30% annual decline in caribou population. In the Wells Gray area there has been a good survival rate of calves during the summer despite the presence of wolves. Seip attributes this success to the availability of much higher alpine summer habitat.

In the absence of wolf control Seip states that we can expect a continuing decline in caribou throughout the highland habitats until they become extinct. The solution is to control predation and increase recruitment. The responseof the caribou population with respect to the wolf control program in the Quesnel Lake area last year indicated that there was little improvement until 80% of the wolves were removed.

Table 2. Mortality causes of radio-collared caribou in southeastern B.C.

Cause	Quesnel Lake	Selkirks	Columbia	Wells Gray	Total	%
Accidents[1]	3	0	4	0	7	23
Bear Predation	2	0	1	3	6	20
Wolf Predation	8	0	0	1	9	32
Poaching	0	2	0	0	2	7.5
Malnutrition[2] or disease	2	0	0	0	2	7.5
Unknown cause	3	0	0	1	4	15
Total	18	2	5	5	30	

[1] includes animals that starved following an accident which prevented movement or feeding

[2] includes sickly animal that was killed or scavenged by a bear

HABITAT USE

Early winter (Nov.-Dec.)

ICH: 800-1300 m

Revelstoke	>90%
Selkirks	12-56%
Quesnel Lake	10-20%
Wells Gray	5-25%

- topography, snowfall, predators, capture bias

ESSF, closed canopy 1500-1800 m

Mid winter (Jan.-Feb.)

ESSF, closed canopy 1500-1800 m

How much is merchantable?
0-50%

Late winter (Mar.-Apr.)

Parkland 1800 m

May

Low elevation

Revelstoke	95%
Quesnel Lake	40%
Wells Gray	25%

Summer(Jun.-Oct.)

Quesnel Lake	subalpine forest	1600 m
Wells Gray	parkland/alpine	1900 m
Revelstoke	subalpine	1500 m

SUMMARY - HABITAT VERSUS PREDATION AS A LIMITING FACTOR FOR CARIBOU

T. Bergerud

Use of the scientific method may allow us to get to the cause of declines in caribou populations. The Slate Islands has been logged and burned; trees were all sixty years old, there were no predators and the arboreal lichen supplies were very limited. Despite these conditions the caribou density is the highest in the world - up to 16 caribou per km^2 (total between 300-600).

Estimates of the population and annual mortality are accomplished by strip census, Lincoln index, pellet counts and one-third of the animals are tagged. The population undergoes tremendous periodic die-offs (as high as 64%) yet the caribou are a long way from becoming extinct. Mortality was not density-dependent even with 10 caribou/km^2. Part of the die-off was breeding related, since only the one to three year olds survived in 1984 while the older animals that had bred did not. (This has some density-dependent implications).

The caribou live on windfall as there is no ground lichen, therefore the caribou don't crater. The islands have low litterfall so when a piece of lichen blows down, a caribou stays by it and defends it until it is eaten up. If a tree is down anywhere on the island, all lichen is gone by morning.

In the literature available, nutritional perinatal mortality occurs only if it is preceded by winter conditions severe enough to kill adults and short yearlings. To determine death of calves in the first ten days after calving checks must be made every day to determine cause of death. In the Spatsizi after seven days - 30% of calves including bodies were gone - grizzly bear predation suspected. Carcass must be skinned to positively dismiss predation as cause.

Fecal nitrogen levels during die-off (Slate Islands) are equal to Quesnel Lake levels but if starvation is affecting survival, "bring in the bodies". The critical habitat for caribou is the calving range. Barren ground (or migratory) caribou space away frompredatorsby travelling at right angles to the tree line when going to calving grounds. Woodland caribou (non-migratory) use spacing away from each other as a major strategy during calving. At this time (spring) these caribou have three strategies: 1) Calve on islands 2) have small aggregation size 3) calve at low densities.

Investigation of three hypotheses: 1)a shortage of space (predators) 2) a shortage of time for feeding and 3) a shortage of food. Many of the caribou herds are surviving at densities of .4/km^2 or less. The George River herd is

dying off from a shortage of summer food (hypothesized problem of social facilitation; doing as the neighbours do and not feeding).

Calving grounds selected as an anti-predator strategy also suffer because of food shortages. As herds increase in size (e.g., Ungava) the animals don't stop running (from flies, wolves) despite good range availability, therefore there is a shortage of time to fatten. Caribou can solve this problem by breaking into smaller groups, stop running and by eating a sufficient amount.

Caribou can exist at high densities (16/km^2). They are not limited by food but by space - they need sufficient space to reduce interactions with predators. Caribou in the Slate Islands make out on a lot less food that other herds; excess energy costs in large antlers end up killing the animal so 40% of males have no antlers. Jacques Costeau, trying to film the Slate Island caribou by helicopter had 7 caribou die from the additional energy expenditure used in the chase. Populations at low density are relatively secure unless moose are around to maintain predator densities. But if the greenhouse effect is correct and temperatures increased by 3°, caribou are doomed and moose will take over the north.

CARIBOU INVENTORY AND POPULATION DYNAMICS

A SUMMARY OF INFORMATION PRESENTED AT THE CARIBOU WORKSHOP

Ian Hatter, Wildlife Inventory Specialist

The caribou inventory workshop was prompted by a recent report released by the Ministry of Environment and Parks and the Spatsizi Association of Biological Research. (Hatler, D.F. 1987. Perspectives on inventory of caribou in British Columbia. Wildlife Report No. R-12, Ministry of Environment and Parks, Wildlife Branch, Victoria, B.C. 93 pp.) in which the overall conclusion was that caribou inventory in British Columbia has produced unsatifactory data since it commenced in the 1970's. Given the need for reliable caribou inventory data for harvest management (e.g., setting harvest quotas), and monitoring other management programs (e.g., wolf control), the workshop was organized with the following objectives:

1) review current inventory procedures for caribou and the reliability of recruitment estimates.

2) standardize caribou inventory procedures to promote province wide consistency and comparability of data.

3) investigate sampling systems for caribou (e.g., mark-recapture, stratified random sampling).

1) PRESENT STATUS OF CARIBOU INVENTORY IN B.C., Ian Hatter, Wildlife Branch, Ministry of Environment, Victoria, B.C.

Prior to the mid 1970's, there were relatively few surveys for caribou anywhere in British Columbia. Bergerud (1978, The Status and Management of Caribou in British Columbia. Wildlife Branch Report, Ministry of Environ., Victoria, 150 pp.) surveyed much of northern B.C. in the fall of 1977 and winter of 1978, focussing on rut concentration areas. His report outlined the first population monitoring program for caribou which consisted of:

1) conducting inventories on a herd unit basis;
2) timing surveys to coincide with the fall rut (October) or winter;
3) classifying caribou to male (bull), female (cow), and calf; and
4) using a recruitment-mortality equation (Demographic Method) to estimate rate of increase.

Demographic Method

1. R = % CALVES IN FALL - 2%
2. Mn = 13.8 -(.3856 * R)
3. L = (100 - Mn)

   (100 - R)

where L = Finite Rate of Increase
Mn = Natural Mortality Rate (% adults)
R = Recruitment Rate (% calves)

EXAMPLE: 15 % calves observed in October Rut Survey

1. R = 15% - 2% = 13%
2. Mn = 13.8 -(.3856 * 13)
   = 8.8 %
3. L = (100 - 8.8)

   (100 - 13.O)
   = 1.048 or an annual growth rate of 4.8 %

The standard caribou survey in the province now involves the following elements: (from Hatler 1987)

1) Use of an aircraft, usually a jet helicopter.
2) Designation of one or more survey areas, usually defined by lower elevational or open-habitat limits.
3) Total survey coverage of the designated areas by flight patterns judged, in flight, to result in contacting the most animals.
4) Attempted location and enumeration of all animals present in the designated survey areas.
5) Classification of each group encountered to one of four defined levels of detail.

Four categories of surveys are recognized depending on the timing of the survey. These include rutting aggregation surveys in the northern third of the province, where the focus is on collecting recruitment data (usually % calves); winter (late March - early April) surveys, where caribou use more open habitats near or above timberline and sex segregation is minimal (Quesnel Highlands, Wells Gray Park, Columbia Mts.); summer snowpatch surveys, formally used in Wells Gray park but are now discontinued; and post-calving surveys (Itchas-Ilgachuz-Rainbows, Tweedsmuir-Entiako) for asssesing early calving success.

Most of the advancement in caribou inventory since Bergerud's report has come from the use of radio-collared animals to estimate herd size by mark-recapture. A major drawback to this methodology has been the high cost associated with collaring large numbers of caribou to ensure an unbiased sample. Although confidence limits can be calculated from the present surveys, they may be biased due to the small sample sizes.

Some Mark-recapture Estimates from B.C. Caribou Herds

AREA	ESTIMATOR	POPULATION		N	MARKED	OBSERVED
Columbia	Single	186	38%	111	9	5
Mts.	MR	200	31%	140	9	6
Itcha	Multiple	1589	25%	991	29	17
Ilgachuz	MR			508	29	9
Spatsizi	Multiple	2256	29%, -18%	1075	84	36
Park	Telemetry	2114	29%, -18%	1041	84	36

Another advancement has been to conduct surveys over 2 or more seasons in order to provide a more accurate estimate of caribou numbers and composition, than can be obtained from a single survey conducted in one season. For example, in the Itchas-Ilgachuz-Rainbows, a post-calving survey that incorporates a sightability index is used to estimate total numbers of females (including non-parous females). This is followed by an October (rutting aggregation) survey to estimate bull numbers from the fall bull:cow ratio.

Bergerud (in press) has recently revised the recruitment-mortality equation for use with the Demographic Method.

2) LIMITATIONS OF CARIBOU SURVEY METHODOLOGY IN NORTHERN B.C., David Hatler, Spatsizi Assoc. for Biol. Research (SABR) (absent, presented by Ian Hatter)

Hatler (1987) identified potential shortcomings of the traditional fall rut counts for obtaining population numbers and sex/age composition for caribou.

Based on inventory-related studies in the Spatsizi Wilderness Park area, fewer than

half of the radio-collared animals, and therefore possibly less than half of the population, were seen during aerial surveys at rut time.

Caribou Sightability on Rut Survey Areas, Spatsizi Park

Year	No.of Collared Caribou	No. of Collared Caribou Seen	Sightability
1981	8	5	.63
1982	3	1	.33
1983	25	8	.32
1984	26	13	.50
1986	22	9	.41
81-86	84	36	.43

This may occur because a portion of the animals were not present in the designated, upland survey areas. Of particular concern was the result that females with calves were found in the fall rut concentration areas significantly less often than females without calves.

Occurrence of Collared Females in Rut Survey Areas (1981-86)

	Present	Absent	% Present
Female with calf	9	12	43
Female without calf	39	12	76

These results are supported by the rut surveys, where in 4 out of 5 years, the collared sampled showed a higher calf:100 female ratio than than did animals classified in the corresponding rut surveys.

Relationship Between Calves:100 Females in the Collared and Survey Sample

Year	Collared Sample		Survey Sample		
	N	Calves:100 F	N	Calves:100 F	P
1981	7	28.6	305	11.5	.167
1982	4	25.0	722	13.9	.521
1983	20	10.0	274	23.7	.158
1984	20	45.0	431	26.7	.073
1986	18	44.4	483	24.4	.055

The biological basis for these findings is thought to be related to the animal's strategy for protecting young from predators. Throughout summer and fall, females with calves move less and generally remain in smaller groups than do females that are nonparous or have lost their calves. These movement and grouping patterns hold through the rut period. Since predators (wolves and grizzly bears) are attracted to the large aggregations of caribou in the upland habitats during the fall, the avoidance of these areas by some successful mothers would infer a selective advantage to their offspring.

The large group sizes encountered during the fall introduces another source of bias since many groups are too large to classify completely, and because there is an inverse relationship between group size and calf abundance.

The general conclusion was that fall surveys appear to be of limited usefulness for determining caribou population status (recruitment, herd size) in Spatsizi Park, and probably in other areas of northern British Columbia. The overall conclusion was that caribou inventory in the province has produced unsatisfactory data since it commenced in the 1970's.

3) SAMPLE BASED SURVEY DESIGNS FOR CARIBOU

a) STRATIFIED RANDOM BLOCK, Rick Farnell, Fish and Wildlife Branch, Yukon Territory

Prior to initiating a stratified random block (SRB) survey, caribou are radio-collared and tracked for 3 to 4 years to gather life history information, seasonal movements, and distribution to assist in delineating the survey area. The telemetry studies have indicated that most caribou occupy a discrete winter range. Because caribou have a confined distribution at this time of year, it is the season of choice for conducting population surveys by this method.

The survey procedures are a modification of the method described by Gasaway *et al.* (1986. Estimating moose population parameters from aerial surveys. Biol. Papers of the Univ. of Alaska. No. 22. 108pp.). The surveys are done in March. The entire survey area is segregated into sampling units (S.U.'s) of 15 to 20 km^2. Relatively large S.U.'s are chosen due to large movements by caribou. A fixed wing aircraft is initially used to stratify the survey area. Where required, S.U.'s are redrawn during the stratification flight (e.g., where a sampling unit includes both high and low density strata). The actual survey is done by helicopter at an average search intensity of 3.7 minutes/km^2. Variance is substantially reduced if all of the high stratum is counted and the other strata randomly sampled (although acceptable confidence limits are possible without counting all of the high stratum). A sightability correction factor (SCF) is used for animals missed during the survey. A portion of a S.U. is selected and reflown at an average search intensity of 11.4 min/km^2. The intensive search units include S.U.'s that have large numbers of caribou. High, moderate and low forested areas are searched to develop an average SCF. In the Finlayson survey, telemetry results indicated that 37% of the caribou moved across S.U. boundaries. The SCF from 8 high intensity search plots was 1.494. The final estimate had a precision of 12 % with 95% confidence limits.

There is a large disparity in the sex/age composition of caribou in different portions of the winter range. Because of the differential use of the winter range by different sex/age classes, SRB surveys appear to be the only suitable method for obtaining unbiased sex/age ratios in winter.

Comparison of winter surveys with fall surveys indicated that the rut counts only underestimated the percentage of calves by 2%. The % calves statistic, in fall, therefore appears to be a reliable estimate of recruitment in the Yukon.

b) MARK-RECAPTURE

Radio-telemetry, T. Smith, Fish and Wildlife, Ministry of Environ., Williams Lk.; D. Cichowski, Univ. of British Columbia, Vancouver

Radio-telemetry surveys of the Itcha-Ilgachuz-Rainbows (IIR) and Tweedsmuir-Entiako (TE) herds have focused on inventory development through measuring caribou sightability and biases in recruitment estimates during the post-calving, rut, and late-winter periods.

Whereas approximately 85% of the collared female caribou from the IIR herd were present above treeline in June, and about 75% in October, only 40% were present in March. Fewer collared females were also observed in the TE herd during March than in June and October, although the proportion of collared females present was much less (about 35% in June, 40% in October, and 15% in March).

Based on June surveys for the IIR herd, (when the highest proportion of collared animals were present above treeline), simple mark-recapture estimates from 1985 to 1987 were 1106, 1253, and 1331 caribou, respectively, suggesting that, on average, 73% of the caribou were observable. Uncorrected counts could not be used as a trend index, since observed caribou numbers decreased (936, 895, and 856).

Population Estimates for the Itcha-Ilgachuz Caribou in June

Year	No. of Females/ Calves Counted	Sightability	Estimate
1985	936	.846 (11/13)	1106
1986	895	.714 (10/14)	1253
1987	856	.643 (9/14)	1331

Because of the low proportion of collared caribou in the alpine in the Tweedsmuir-Entiako in October, it is believed that only 25 to 43% of the caribou were seen.

Population Estimates for Tweedsmuir-Entiako Caribou in October

Year	No. of Females/ Calves Counted	Sightability	Estimate
1985	102	.250 (3/ 4)	408
1986	202	.429 (6/14)	471

Rut counts do not, in these areas, provide, useful estimates of population numbers or trend, unless corrected with a reliable sample of marked (radio-collared) to unmarked caribou.

A comparision of the proportion of females with calves in the alpine to those below treeline in the IIR herd indicated that there was no significant difference among the radio-collared sample in June, October, or March. Among the non-collared sample, significantly more females with calves were seen above treeline than below treeline during June and March. There was no difference in October.

Caribou Females with Calves in the Alpine and below Treeline in Itcha-Ilgachuz-Rainbow Herd (1985-87)

	% Females with Calves in the Alpine		% Females with Calves below Treeline		
	%	N	%	N	P
Radiocollared Females					
June	63	(49)	50	(8)	NS
October	19	(27)	0	(7)	NS
March	33	(12)	19	(21)	NS
Total Females					
June	42	(2027)	16	(32)	<.05
October	21	(976)	25	(96)	NS
March	31	(395)	15	(289)	<.05

In the TE herd, there were significantly more females with calves in the alpine in June. There were no significant differences in October and March.

Caribou Females with Calves in the Alpine and below Treeline in Tweedsmuir-Entiako (1985-87)

	% Females with Calves in the Alpine		% Females with Calves below Treeline		
	%	N	%	N	P
Radiocollared Females					
June	92	(12)	35	(23)	<.05
October	7	(15)	18	(22)	NS
March	0	(3)	0	(21)	NS
Total Females					
June	82	(2027)	25	(44)	<.05
October	11	(342)	16	(66)	NS
March	14	(96)	8	(130)	NS

These data do not support the Spatsizi findings that recruitment estimates from rut surveys are biased as a result of differential distribution of females with calves and females without calves.

There was a relatively poor correlation between radio-collared calf:female ratios and uncollared calf:female ratios, although March surveys appear promising. More years of data are required to statistically define the relationship.

Aerial Paint Spraying, J. Elliott, Fish and Wildlife, Ministry of Environ., Fort St. John (absent - presented by I. Hatter)

An experimental mark-recapture survey was conducted on the Horseranch Range using a fast drying, non-toxic paint sprayed from a helicopter. On 22 September 1987, 78 caribou were marked on about 1/5th of the mountain block. The remainder of the range was not visited. Two mark recapture surveys were conducted on September 30th, and October 14th.

Calf:female ratios were highest on both the marked and unmarked area on the first visit, and declined during each subsequent survey. Ratios were lower in the alpine than in forested habitats.

	Calves per 100 Females				
	Undisturbed Area	Once Disturbed		Twice Disturbed	
		alpine	forest	alpine	forest
Marked	43.7 (22/09)	11.1 (30/09)	39.1 (30/09)	10.3 (14/10)	20.0 (14/10)
Unmarked	42.4 (30/09)	23.5 (14/10)	37.5 (14/10)		

The preliminary conclusion was that multiple surveys disturb caribou such that fewer calf:female groups are observed with each repeat survey. The initial marking procedure, in particular, appears to disturb caribou. Although the marking technique worked well, the disturbance factor associated with marking the caribou and replicating the surveys suggests the technique holds little promise as a census technique. The traditional rut survey may still be the best inventory method available for this area. It is noteworthy, however, that replicate surveys of the Itchas-Ilgachuz-Rainbow herd in June did not significantly affect caribou numbers.

4) CLASSIFICATION CRITERIA FOR CARIBOU, G. Jones, B.C. Parks, Ministry of Environ., Victoria

Caribou calves can only be reliably classified by the short face. Classification of long yearlings is no longer done. Adult caribou can not be reliably classified from the side. While sexing caribou (adults and calves), do not look for the penis or use the size of the antlers, rather the vulval patch technique should be used. Antler sizes can be used to identify bull categories.

Large Bull - with large, mature complement of antler, usually with a palmated brow tine ("shovel")

Medium Bull - distinguishable as a male in having larger antlers than females, but with brow tines not palmated.

Small Bull - not distinguishable from females by antler development; classified on basis of lack of black vulval patch when viewed from the rear.

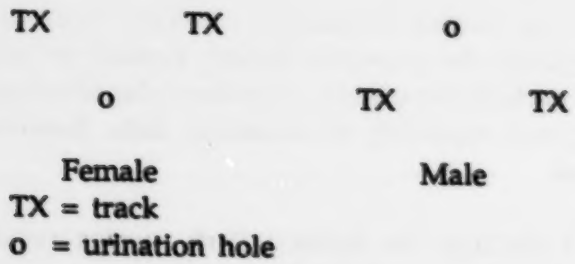
Adult Female(yearling or older)- with a calf, and/or with a black vulval patch when viewed from the rear.

Calf (young-of-the-year) - considerably smaller than adults, usually with darker pelage and with short, velvet antlers (up to 30 cm long, and usually single spikes, but occasionally forked). **Note:** male and female calves can be distinguished by presence/absence of the vulval patch, as described for adults.

Unidentified Adult - animal not seen well enough to determine sex, but known not to be a calf.

Unclassified - neither age nor sex determined.

It is also possible to sex caribou from tracks and urination in the snow, i.e.,



Classification Standards

Level 1: calves and unclassified adults.

Level 2: calves, large bulls, and unclassified adults.

Level 3: male and female calves, bulls and adult females.

Level 4: calves (sexed, if possible), bulls (large, medium, and small), and adult females.

5) HOW IMPERFECT IS CARIBOU INVENTORY? R. Page, Ministry of Forests, Victoria, B.C.

This paper presents an alternative view on the status of caribou inventory in British Columbia. In contrast to Hatler (1987), it strongly argues that % calves is a useful index to recruitment. Using rut surveys from several northern caribou herds, recruitment rates were consistent between different herds from 1976 to 1986. The areas closest to each other showed the highest correlations, and the Horseranch (with wolf reduction) the least. Correlations were much poorer for calves:100 females. Since % calves was only sometimes correlated with calves:100 females from the same herd, it was suggested that adults are not being adequately sexed.

The discrepancy between Hatler (1987) and these results were explained by: 1) females and males were incorrectly classified in rut surveys; and 2) the collared sample was biased and did not represent the movement patterns or reproductive dynamics of the herd (primarily because of the high number of old females). It was concluded that the % calf estimate from aerial surveys is a good indicator of calf recruitment and possibly the very best we can get.

6) WORKSHOP DISCUSSION AND POINTS OF CONSENSUS

1) Caribou life history data, as revealed from radio-telemetry studies, suggests that it is neither practical nor possible to develop one standard inventory procedure for caribou in British Columbia. Rather, local differences in caribou biology throughout the province dictate a need to modify survey design and timing to each caribou herd. Caribou classification criteria, as well as the recording and reporting of inventory data, however, can and should be standardized.

2) In contrast to Hatler's findings for Spatsizi Park, survey results from the Yukon, and southern B.C. suggest that reliable estimates of recruitment are

possible from rut surveys. The Horseranch studies suggest that rut surveys may still be the best option, an opinion also echoed by Page. It is evident, however, that only a portion of the caribou are present on the survey areas, and the counts can not be used to estimate population numbers or trends. The recruitment-mortality equation originally developed by Bergerud (1978) and refined by Bergerud (in press) may still offer the most cost-effective means for determining population status for some caribou herds.

3) Mark-recapture surveys appear promising, at least for southern B.C. herds. A relatively large sample of caribou (30+ animals) combined with high sightability (>70%) is required to make this method effective. Multiple mark-recapture surveys are particularly effective as a means for evaluating the reliability of single count surveys (accuracy and precision), for testing disturbance, and for measuring sightability. Aerial paint spraying, as a means for increasing sample size, should receive further testing before it is dismissed as unreliable.

4) Stratified random block surveys should be tested in northern British Columbia. The sightability correction factor (SCF) should be less than 2.0 for this method to be effective.

5) For some herds, it is necessary to conduct surveys at different times of the year (e.g., postcalving, rut, post-rut, late winter), in order to obtain complete demographic information on recruitment, sex ratios and total numbers.

6) There is considerable discrepancy in the reporting of % calves and calf:female ratios from the same survey by various sources (see below). In most cases, the differences are minor. However, this is one source of error that can and should be eliminated. Since most of the differences are probably related to how unclassified animals are treated in calculating ratios, individuals citing survey results should indicate the number of males, females, calves, and unclassified adults. They should also state how sex/age ratios were calculated (e.g., were partially classified groups included or deleted).

Calf Recruitment (% Calves) at 5 Months - Kawdy Plateau (sample size shown in brackets)

Ref. / Year	Bergerud Elliott (1986)	McGregor (1984)	Hazelwood (1979)	Hatler (1980)	Van Drimmelen (1983)
1976					
1977	5(721)	5(721)			
1978	22(183)	22(223)			
1979	12(547)	20(321)	11.7(321)		
1980	18(194)	17(550)		17.9(591)	
1981					
1982	8(362)				
1983	15(312)				14.7(312)

Calf Recruitment (% Calves) at 5 Months - Lawyers Pass (sample size shown in brackets)

Ref. / Year	Bergerud Elliott (1986)	Jones (1982)	Watts (pers. commun.)	McGregor (1984)
1976	12(69)	11.6(69)		
1977	12(825)	11.8(825)	11(670)	12(825)
1978	11(457)	10.3(493)	11(848)	10(493)
1979	8(623)	7.5(623)	8(270)	6(282)
1980	16(290)	16.2(290)	18(164)	16(95)
1981	5(161)	5.0(161)		
1982	11(256)	10.5(256)		
1983	14(214)			

Calf Recruitment (% Calves) at 5 Months - Level Mountain (sample size shown in brackets)

Ref. / Year	Elliott *et al.* (1984)	Bergerud Elliott (1986)	McGregor (1984)
1977	5.7(228)	6(228)	5(630)
1978	24.9(229)	25(229)	25(286)
1979	9.4(286)	9(286)	7(473)
1980	16.3(184)	16(184)	16(311)
1981	6.5(108)	6(108)	
1982	0.7(153)	1(129)	

7. DEFINITIONS:

Population: the total distribution of an interbreeding group of animals.

Management Herd: an identifiable grouping of animals for which recruitment and mortality factors can be demonstrated to be similiar and to which management strategies can be employed.

POPULATION PARAMETERS OF CARIBOU IN WEST CENTRAL B.C.

D. Chichowski, University of B.C., Vancouver

Population estimates and calf recruitment estimates of woodland caribou populations in British Columbia are often based on censuses conducted in open habitats, primarily alpine habitat (Bergerud 1978). However, data from radio-collared caribou in Spatsizi Provincial Park suggested that sex/age class composition of caribou found in open habitat was not representative of sex/age class composition of the whole population (Hatler 1987). Also, it is difficult to assess what proportion of the population is present in open areas during censuses. With a sample of radio-collared caribou, the proportion of the population present in open areas can be determined and population size can be estimated using a modification of the Peterson mark-recapture method (Seber 1982):

$$1.\quad \frac{N}{C} = \frac{R}{A} \quad \text{or} \quad 2.\quad N = \frac{RxC}{A}$$

where R = # of radio-collared caribou, C = # caribou counted in the alpine, A = # of radio-collared caribou found in the alpine and N is the population estimate.

In this paper, data from a 3-year study of radio-collared caribou from the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow caribou populations were used to estimate population size and to assess reliability of recruitment statistics based on censuses of caribou found in alpine areas.

Population Estimates

In the Itcha-Ilgachuz-Rainbow area, the majority of radio-collared caribou were found in alpine habitat during June and October surveys but not during March surveys (Fig. 1). Although less than 50% of radio-collared caribou were found above treeline during any of the surveys conducted in the Tweedsmuir-Entiako area, a greater proportion of radio-collared caribou were found in alpine habitat during October surveys than during June or March

surveys (Fig. 1). In the Tweedsmuir-Entiako area, radio-collared caribou found above treeline during calving were located throughout northern Tweedsmuir Park and mountainous areas to the west so a total survey to count caribou in alpine areas in June was not feasible. In contrast, animals found in alpine habitat during October were generally concentrated in the Quanchus Mountains. Consequently, all alpine areas in the Quanchus Mountains were surveyed during October 1986 and 1987 and the proportion of radio-collared caribou sighted above treeline was recorded. In the Itcha-Ilgachuz-Rainbow Mountains, all alpine areas were surveyed during June censuses.

During June censuses of the Itcha-Ilgachuz-Rainbow Mountains, 1002, 986 and 884 cows, yearlings and calves were counted and classified above treeline in 1985, 1986 and 1987, respectively. Using equation 2 and the proportion of radio-collared females sighted above treeline (1985-15/17, 1986-16/20, 1987-14/20), the population of cows, yearlings and calves was estimated at 1136, 1233 and 1263 in June 1985, 1986 and 1987, respectively. The adult bull population was estimated at 213, 200 and 221 bulls in 1985, 1986 and 1987 by applying the October bull:cow ratio to the corrected number of adult female caribou in June and adding the number of bulls harvested. Total population estimates for June 1985, 1986 and 1987 Itcha-Ilgachuz-Rainbow caribou were 1349, 1433 and 1484 caribou, respectively. The estimate for 1987 was probably low because the Rainbow Mountains were not adequately surveyed. Results from three replicate surveys conducted in the Itcha Mountains during late June and early July 1985 (aerial census - June 18, June 27; ground survey - July 8) suggest that surveys conducted in the Itcha-Ilgachuz-Rainbow Mountains were relatively precise (Table 1).

In the Tweedsmuir-Entiako area, a total of 104 and 202 animals were counted in alpine areas of the Quanchus Mountains during October 1986 and 1987, respectively. Using equation 2 and the proportion of radio-collared caribou seen in alpine habitat in the Quanchus Mountains (1986-3/12, 1987-7/14), the population was estimated at 416 caribou in October 1986 and 404 caribou in October 1987.

Alpine Censuses

During aerial surveys, radio-collared caribou cows were located and presence or absence of a calf was determined. In the Itcha-Ilgachuz-Rainbow area in June, 45-80% of radio-collared cows had surviving calves but by October, 6-45% of radio-collared caribou had surviving calves (Fig.2). Percentage of adult radio-collared female caribou with calves varied between 6% and 35% in March. In the Tweedsmuir-Entiako area, 25-65% of the radio-collared caribou cows had surviving calves in June but by October, few calves had survived (Fig.2). No radio-collared female caribou had a calf survive until March in 1985/86 and 1986/87. In 1987/88, 2 of the 14 radio-collared caribou had calves survive until March 1988. Most calf mortality occurred between June and October in both Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas.

Caribou associated with radio-collared animals and caribou sighted opportunistically were also counted and classified. Proportion of radio-collared cows with calves and proportion of all cows counted with calves were compared between animals found above and below treeline. During the October surveys in the Tweedsmuir-Entiako area, the comparisons were made between alpine areas in the Quanchus Mountains and all other areas that animals were found.

The calf/cow ratio of all adult female caribou counted during June was greater for cows that were found in alpine habitat than for cows that were found below treeline, in both the Tweedsmuir-Entiako (X^2=22.4, $p<.05$) and Itcha-Ilgachuz-Rainbow (X^2=4.4, $p<.05$) areas (Table 2). In the Tweedsmuir-Entiako area, the calf/cow ratio of the radio-collared caribou sample was also greater in the alpine than below treeline (X^2=14.3, $p<.05$). During October surveys there were no differences between proportion of cows with calves found above treeline and proportion of cows with calves found below treeline in either the radio-collared sample or the total sample in the Itcha-Ilgachuz-Rainbow area. In the Tweedsmuir-Entiako area in October, the proportion of cows with calves above treeline was less than the proportion of cows with calves below treeline in the radio-collared sample $p<.10$ (X^2=2.77) but not in all the adult female caribou counted. The total count in March

indicated that proportion of cows with calves in the alpine was greater than proportion of cows with calves below treeline in Itcha-Ilgachuz-Rainbows at $p<.05$ ($X^2=31.9$) and in Tweedsmuir-Entiako at $p<.10$ ($X^2=31.9$). These results indicated that aerial censuses of alpine areas during June and March in both Itcha-Ilgachuz-Rainbow and Tweedsmuir-Entiako areas were biased towards animals with surviving calves. In Tweedsmuir-Entiako, censuses of alpine areas during October were biased towards cows without calves.

Summary

1. Peterson population estimates indicated 1300-1500 caribou in the Itcha-Ilgachuz-Rainbow area and 400-420 caribou in the Tweedsmuir-Entiako area.

2. Alpine surveys in June and March were biased towards cows with calves in the Itcha-Ilgachuz-Rainbow and Tweedsmuir-Entiako areas. In Tweedsmuir-Entiako, October counts were biased toward cows without calves.

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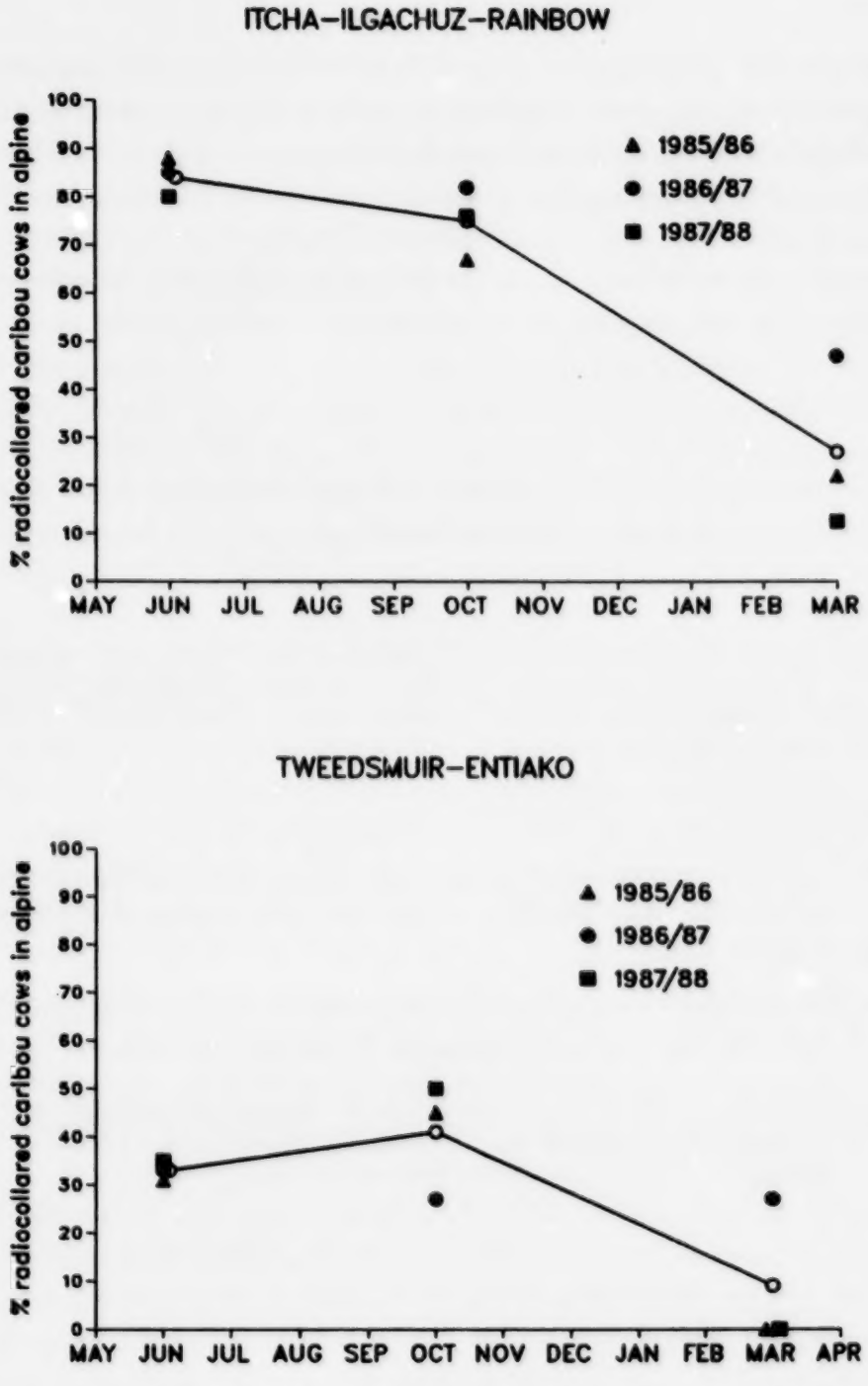
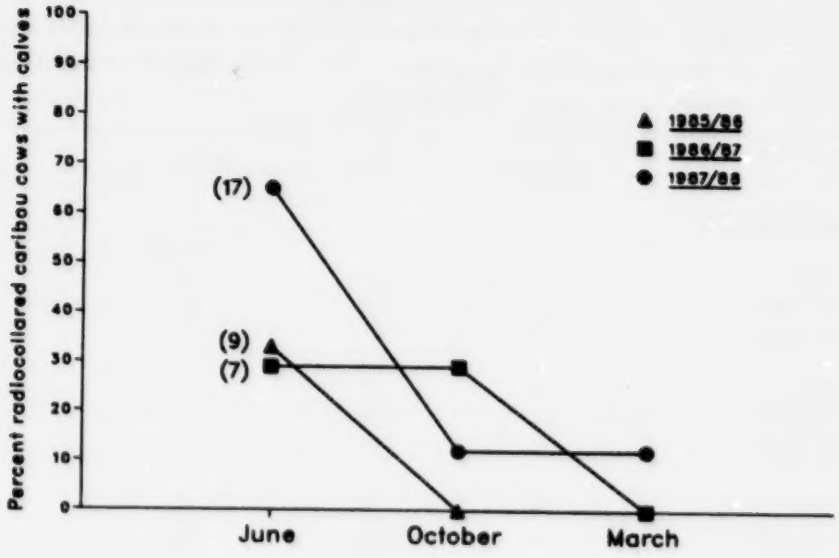


Figure 1. Percentage of radio-collared caribou found in alpine areas during June, October and March censuses in the Itcha-Ilgachuz-Rainbow and Tweedsmuir-Entiako areas, April 1985 - March 1988.

TWEEDSMUIR–ENTIAKO



ITCHA–ILGACHUZ–RAINBOW

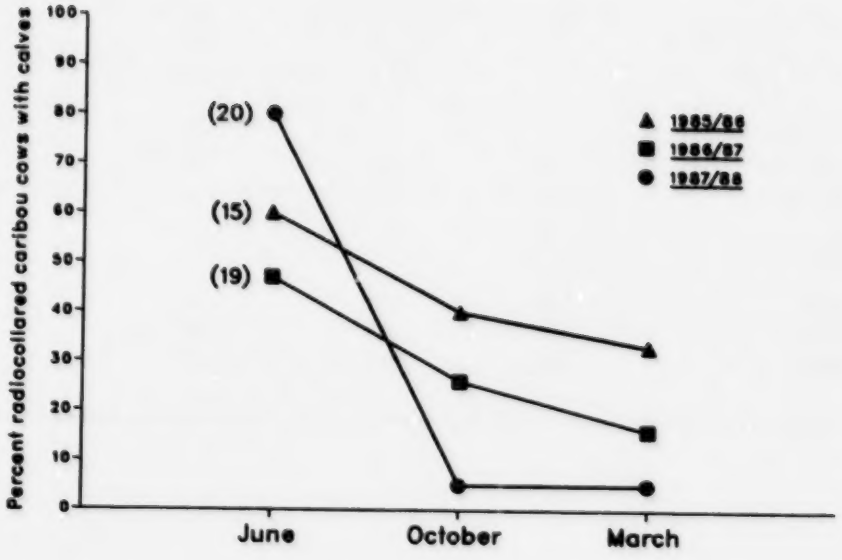


Figure 2. Percentage of radio-collared caribou cows with calves during June, October and March calf surveys in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas, April 1985 - March 1988.

Table 1. Number of caribou of each sex/age class counted both above and below treeline during aerial surveys in June, October and March in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow study areas (April 1985 - March 1988).

Date	Calves	Cows	Bulls	Total
Tweedsmuir-Entiako				
June 16, 1985	9	28	0	37
October 6, 1985	10	114	31	155
March 19, 1986	8	81		89
June 23, 1986	6	20	0	26
October 7, 1986	13	102	22	137
March 15, 1987	15	135		150
June 16, 1987	14	20	0	34
October 20, 1987	20	192	33	245
March 11, 1988	12	123		135
Itcha-Ilgachuz-Rainbow				
June 18-19, 1985	287	721	58	1063
October 18, 1985	46	187	30	263
March 18, 1986	83	277	51	411
June 25-26, 1986	302	706	61	1069
October 10, 1986	105	407	87	599
March 14-15, 1987	85	407		492
June 18-19, 1987	273	620	78	971
October 21, 1987	82	483	92	657
March 10, 1988	47	338		385
Itcha Mountains				
June 18, 1985	130	351	8	523
June 27, 1985	124	348	36	508
July 8, 1985	130	345	60	535

Table 2. Proportion of caribou cows with calves in the alpine and below treeline in the Tweedsmuir-Entiako and Itcha-Ilgachuz-Rainbow areas from 1985 - 1988 combined. (N) = number of cows counted.

DATE	PROPORTION COWS WITH CALVES ALPINE	PROPORTION COWS WITH CALVES BELOW TREELINE	SIGNIFICANCE a = .05	SIGNIFICANCE a = .10
RADIO-COLLARED CARIBOU				
Tweedsmuir-Entiako				
June	.933 (15)	.238 (21)	SIG	SIG
October	.063 (16)	.222 (18)	NS	SIG
March	.000 (0)	.056 (36)	NS	NS
Itcha-Ilgachuz-Rainbow				
June	.625 (48)	.667 (9)	NS	NS
October	.275 (40)	.167 (12)	NS	NS
March	.308 (13)	.135 (37)	NS	NS
TOTAL CARIBOU				
Tweedsmuir-Entiako				
June	.800 (25)	.209 (43)	SIG	SIG
October	.096 (343)	.154 (65	NS	NS
March	.151 (86)	.087 (253)	NS	SIG
Itcha-Ilgachuz-Rainbow				
June	.424 (2017)	.233 (30)	SIG	SIG
October	.211 (960)	.256 (117)	NS	NS
March	.281 (519)	.137 (503)	SIG	SIG

HOW IMPERFECT IS CARIBOU INVENTORY?

Rick Page, Research Branch, Ministry of Forests, Victoria, B.C.

Caribou inventories are imprecise, biased and "of limited usefulness" according to the latest review by Hatler (1987). The situation may not be as bleak as that one opinion suggests. I present a very cursory version of my opinion.

In northwestern B.C., a number of caribou herds were surveyed during the rut from 1976-86. We can assess the usefulness of this information in comparisons of the survey results between areas, between different techniques and by comparison to other independent but related sources of data. Hatler chose a microscopic view in painting a picture of rut surveys, identifying all the warts and blemishes. I suggest that a macroscopic view of consistency and trends is more relevant to managers and may produce a portrait that instead of being witchlike, shows a woman of considerable beauty indeed.

Caribou Data

1. Total numbers seen

This is the number that most managers want, yet the most difficult to assess. There is no easy comparison of total numbers between herds. Even so, the most cursory examination of CLI survey maps from 1969, the extensive surveys of 1976-78 and current caribou inventories reveals an incredible crash of caribou numbers in northern B.C. The data on this issue are less clear than others, so I will leave this discussion to a later time.

2. % Calves

Classification of animals as calves or not is the easiest of data sources to collect. It does not require complete sightability nor skilled observers. It should be the most reliable statistic.

3. Calves:Female

To gather this information a decision by the observer must be made first as to age, and if the animal is judged not to be a calf, then to sex. Young male caribou have small antlers, while old females have large antlers. Caribou can only be sexed reliably during the rut by close examination of external genitalia. Given the difficulty of sexing large groups of caribou, visibility and movement of an aircraft, it is hard to imagine this statistic replicating the accuracy of % calves. Some authors have suggested that calves:female should be more reliable that % calves, since it eliminates any variation in adult sex ratio. No animal shows more variation in sex ratio than recruitment though, and the second

source of information (sex) will in reality only confound and increase the variability of the estimated recruitment unless sex identification is near perfect.

4. Males:Females

As previously, young caribou are difficult to sex and old caribou lead to visibility biases. Large antlered animals tend to be noted and classified as males, while females and young males are more likely to remain unknowns. Since this introduces a strong bias, it is critical that virtually all caribou are sexed (i.e., no unknown adults) for the last two categories to be valuable.

5. Indices

Though rarely used in B.C., animals seen/km hiked or flown can be used to generate population indices. It is the only index used for many species (deer). Many surveys that subjectively attempt total counts are more appropriately viewed as indices.

I have ranked the data above in order of decreasing reliability. Since % calves is the most reliable index, lets look at it. If it fails our tests the others can hardly be expected to do any better.

We have recruitment estimates from Lawyers Pass, Caribou Mt. in Spatsizi, Level Mt., Kawdy Plateau, and the Horseranch Range (Table 1, Fig. 1). The Horseranch is also the site of John Elliott's wolf reduction experiment. In compiling the counts, I found different numbers for the same survey. Having flown a number of them myself, I understand that how and who adds the numbers can change the estimate. I consider this just anouther source of error along with the important components of weather, date and sightability well-treated by Hatler.

Internal Consistency

Are the counts on different herds within the same year generally consistent? A simple correlation matrix of % calves shows very high consistency between most counts (Table 2). The areas closest to each other show the highest correlations, and the Horseranch (with wolf reduction) the least. The average "explanation content" of other surveys is 50%.

A similar matrix of calves:100 females shows no correlations (even though the sample size is smaller). As expected, this statistic appears poorer than % calves.

Comparing % calves to calves:100 females sometimes shows correlation in counts on the same herds. There is a relationship in the data shown by the % calves, but the inclusion of sex ratio almost totally obscures the information - a strong indication that adults are not being adequately sexed.

External Consistency

Bergerud suggested long ago that caribou calf numbers are driven by predation pressure, and that predation is mediated by snow cover at calving. We would expect correlations between calf counts and spring snow conditions and wolf numbers. For the sake of simplicity, I used Cassiar April 1 snow depths and Level Mt. wolf numbers. I know that a more elaborate snow index, better and site-specific wolf estimates, and arcsin transformation all contribute to better relationships, but I am trying to disprove that these surveys will show a relationship's existence, so accept weak correlations.

As Figure 2 clearly shows, there is a consistent trend of poor recruitment after deep spring snows. In the absence of wolves on the Horseranch in 3 years, the relationship disappears. the more the topographical variability, the flatter (less variable) the regressions. Level Mt. wolf numbers also show high correlations with % calves (Fig. 3). A multiple regression of snow and wolves with arcsin transformation of the calf percentages performs even better, explaining up to 75% of the variability in recruitment. Given some error in our estimates of all 3 variables, a better correlation could hardly be expected.

Calves:100 females always performs very poorly.

SABR Collared Animals

Dave Hatler found little correlation between his potentially reliable sample of 30+ collared caribou and 200+ caribou-years and surveyed estimates of recruitment and justifiably rejected the survey results. Can we explain the discrepancy without having to reject the surveys?

As previously mentioned, calves:female is a highly variable and unreliable estimator so it is not surprising that the collared and surveyed samples do not agree (Fig.4). The collared animals also show a consistently higher recruitment ratio than the survey. I suggest that this is explained by two factors:

1) In the survey, females are never classed as males, yet males can be classed as females. This would inflate the number of adult females and bias the calf ratio low.
2) The collared animals are incredibly old, with the majority exceeding 10 years of age. In the only other studies I am aware of that have significant numbers of teenage animals (moose on Isle Royale and in Sweden), teenage moose exhibit alternate year breeding. An old female that is lactating and has successfully reared a calf to the fall, is energetically depressed, does not come into estrus and does not breed. Hatler showed that only one old female in one instance gave birth in two consecutive years. I believe that these teenage caribou may not ovulate if they are

lactating and so would not attend the rutting grounds. This would explain the apparent distance between females with calves and the males at the rut; an otherwise maladaptive and inconceivable breeding strategy.

In fact, the collared females and the % calf counts in the survey correlate well, if the anomalous year of 1983 is removed (Fig. 5). The collared sample is more variable than the surveyed sample, probably due to the small number of animals collared. As Hatler notes "the probability that the composition of a small local sample will accurately reflect that of the total population is slight" (p. 42). Again, the conclusion is that the % calf estimate from aerial surveys is a good indicator of calf recruitment and possibly the very best we can get.

For management purposes, a series of good % calf counts (3) indicates a lack of concern while a number of years of poor recruitment, especially with severe winters, would indicate a need for reduction in harvest or predators. These kinds of information sources are likely sufficient for managers to be confident they are tracking their caribou populations adequately. Hunter success and harvest statistics are unlikely to be of much benefit since caribou vulnerability is so high. Combined with a precise sample-based population estimation every 5 years, calf percentages during the rut should result in a high level of management success.

Table 1. Aerial inventory of caribou herds, wolf density and indices to winter severity.

Year	Caribou Mountain		Lawyers Pass	Level Mountain	
	% Calves	Ca:100 Fem	% Calves	% Calves	Ca:100 Fem
1976	7	10	12	.	.
1977	5	8	12	6	8
1978	13	14	11	25	.
1979	9	12	8	9	14
1980	12	.	16	16	.
1981	9	17	5	6	.
1982	9	13	11	1	.
1983	15	26	14	.	.
1984	13	.	.	.	.
1985	12	.	.	.	.
1986	15	.	.	.	.

Year	Kawdy Plateau		Horseranch Range		Dease Lake Precipitation
	% Calves	Ca: 100 Fem	% Calves	Ca:100 Fem	Jun 1-10 (mm)
1976	.	.	.	.	15
1977	5	.	6.3	.	32
1978	22	.	16.7	24	15
1979	12	24	17.2	25	37
1980	18	.	16.1	27	9
1981	.	.	10.9	18	26
1982	8	.	4.2	7	1
1983	15	24	6.0	8	51
1984	.	.	.	.	14
1985	.	.	.	.	.
1986	.	.	.	.	.

Year	Cassiar Apr 1 Snow Depth	Level Mt. km²/wolf	Horseranch km²/wolf	Collared Ca:100 Fem	Surveyed Ca:100 Fem
1976	147	.	.	.	.
1977	132	89	100	.	.
1978	89	106	124	.	.
1979	142	102	193	.	.
1980	120	96	139	.	.
1981	123	98	90	28.6	11.5
1982	107	.	90	25.0	13.9
1983	95	.	.	10.0	23.7
1984	106	.	.	45.0	26.7
1985	138	.	.	.	.
1986	136	.	.	44.4	24.4

Table 2*a*. Correlations between estimates of % calves in different herds; 5 out of 10 correlations approach significance.

Variable	N	Mean	S.D.	Sum	Min.	Max.
CARMTP	11	10.8182	3.2502	119.0	5.0000	15.0000
LAWYP	8	11.1250	3.3991	89.0000	5.0000	16.0000
LEVELP	6	10.5000	8.6429	63.0000	1.0000	25.0000
KAWDYP	6	13.3333	6.3140	80.0000	5.0000	22.0000
HORSEP	7	11.0571	5.6311	77.4000	4.2000	17.2000

Pearson Correlation Coefficients/Prob >|R| under Ho:Rho=0/No. of Observations

	CARMTP	LAWYP	LEVELP	KAWDYP	HORSEP
CARMTP	1.0000	0.33572	0.76155	0.81773	0.23649
Caribou Mt.	0.0	0.4162	0.0785	0.0468	0.6097
% Calves	11	8	6	6	7
LAWYP		1.0000	0.33827	0.27576	-0.09889
Lawyers Pass		0.0	0.5120	0.5968	0.8329
% Calves		6	6	6	7
LEVELP			1.0000	0.92884	0.76640
Level Mt.			0.0	0.0225	0.0755
% Calves			6	5	6
KAWDYP				1.0000	0.67804
Kawdy Plateau				0.0	0.1388
% Calves				6	6
HORSEP					1.00000
Horseranch					0.0
% Calves					7

Table 2*b*. Correlations between estimates of calves:100 females in different herds. No correlations are significant.

Variable	N	Mean	S.D.	Sum	Min.	Max.
CARMTR	7	14.2857	5.9080	100.0	8.0000	26.0000
LEVELR	2	11.0000	4.2426	22.0000	8.0000	14.0000
KAWDYR	2	24.0000	0.	48.0000	24.0000	24.0000
HORSER	6	18.1667	8.7958	109.0	7.0000	27.0000
HATLERR	5	30.6000	14.6417	153.0	10.0000	45.0000
SPATR	5	20.0400	6.8446	100.2	11.5000	26.7000

Pearson Correlation Coefficients/Prob > | R | under Ho: Rho=0/No. of Observations

	CARMTR	LEVELR	KAWDYR	HORSER	HATLERR	SPATR
CARMTR	1.00000	1.00000	.	-0.53332	-0.88300	0.88147
	0.0			0.3547	0.3110	0.3131
	7	2	2	5	3	3
LEVELR		1.00000	.	.	.	.
		2	1	0	0	
KAWDYR			.	.	.	.
			2	2	1	1
HORSER				1.00000	0.58493	-0.58757
				0.0	0.6022	0.6002
				6	3	3
HATLERR					1.00000	0.32964
					0.0	0.5880
					5	5
SPATR						1.00000
						0.0
						5

Table 2*c*. Correlations between estimates of % calves, calves:100 females, winter severity and wolf numbers.

Variable	N	Mean	S.D.	Sum	Min.	Max.
CARMTR	7	14.2857	5.9080	100.0	8.0000	26.0000
HORSER	6	18.1667	8.7958	109.0	7.0000	27.0000
HATLERR	5	30.6000	14.6417	153.0	10.0000	45.0000
SPATR	5	20.0400	6.8446	100.2	11.5000	26.7000
DEASEPRE	9	22.2222	15.6267	200.0	1.0000	51.0000
CASSSNOW	11	121.4	19.6889	1335.0	89.0000	147.0
LEVELWOL	5	98.2	6.4187	491.0	89.0000	106.0
CARMTP	11	10.8182	3.2502	119.0	5.0000	15.0000
LEVELP	6	10.5000	8.6429	63.0000	1.0000	25.0000
KAWDYP	6	13.3333	6.3140	80.0000	5.0000	22.0000
HORSEP	7	11.0571	5.6311	77.4000	4.2000	17.2000

Pearson Correlation Coefficients/ Prob > |R| under Ho: Rho=0/ No. of Observations

	CARMTP Caribou Mt. % Ca	LEVELP Level Mt. % Ca	KAWDYP Kawdy % Ca	HORSEP Horseranch % Ca
CARMTR	**0.85125**	0.16149	0.45360	-0.18992
Caribou Mt.	**0.0151**	0.7953	0.4429	0.7185
Ca:100F	7	5	5	6
HORSER	-0.09908	**0.72821**	0.59012	**0.98287**
Horseranch	0.8519	**0.1630**	0.2949	**0.0004**
Ca:100F	6	5	5	6
HATLERR	0.09457	1.00000	-1.00000	0.43003
Collared	0.8798			0.7170
Ca:100F	5	2	2	3
SPATR	**0.90026**	-1.00000	1.00000	-0.43297
Surveyed	**0.0372**			0.7149
Ca:100F	5	2	2	3
DEASEPRE	0.11523	-0.09772	-0.10750	-0.10898
Dease Lake	0.7678	0.8539	0.8394	0.8161
Precipitation	9	6	6	7
CASSSNOW	**-0.48330**	-0.52621	-0.56194	0.18087
Cassiar Apr. 1	**0.1321**	0.2835	0.2458	0.6979
Snow Depth	11	6	6	7
LEVELWOL	**0.76392**	0.65819	0.78149	**0.82494**
Level Mt.	**0.1327**	0.2272	0.2185	**0.0856**
km^2/wolf	5	5	4	5

Figure 1. Northern BC Caribou Surveys

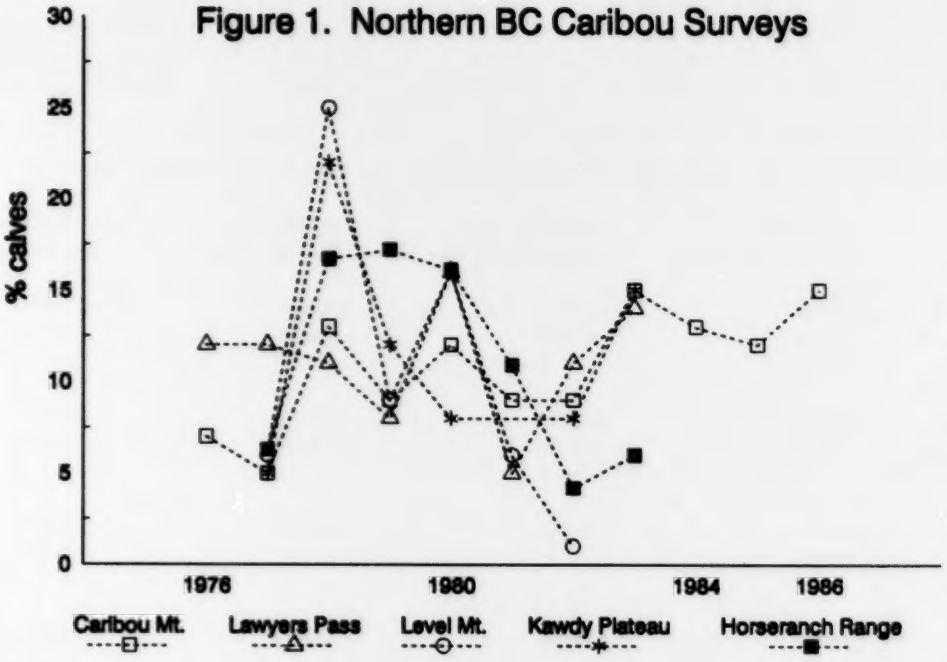


Figure 2. Fall Calves and Spring Snow Depths

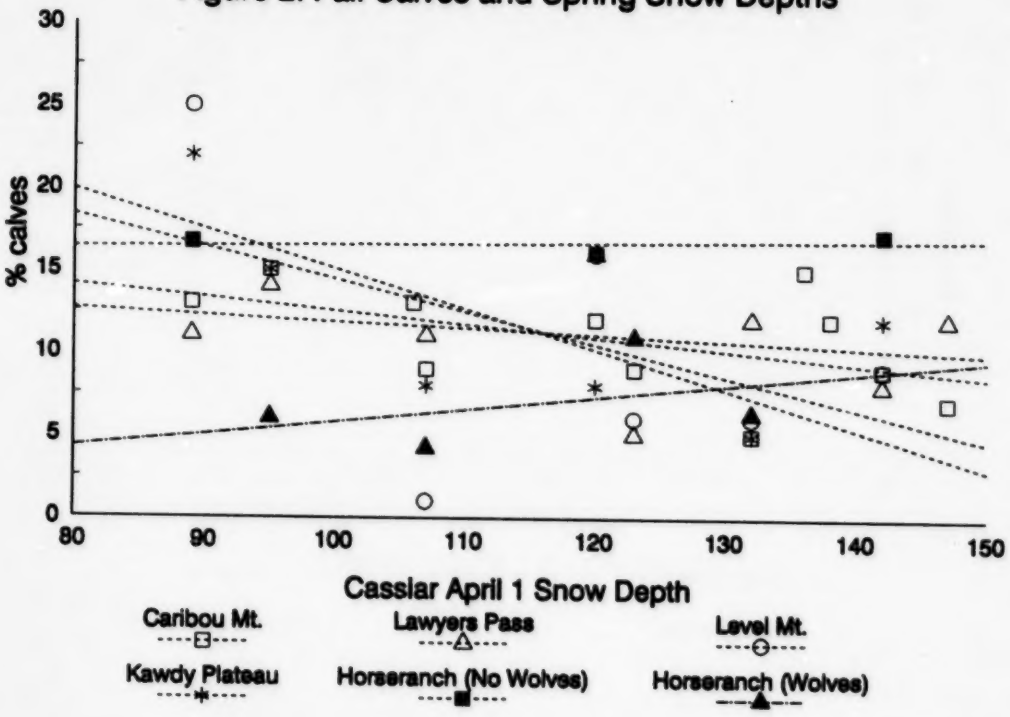


Figure 3. Fall Calves and Wolf Density

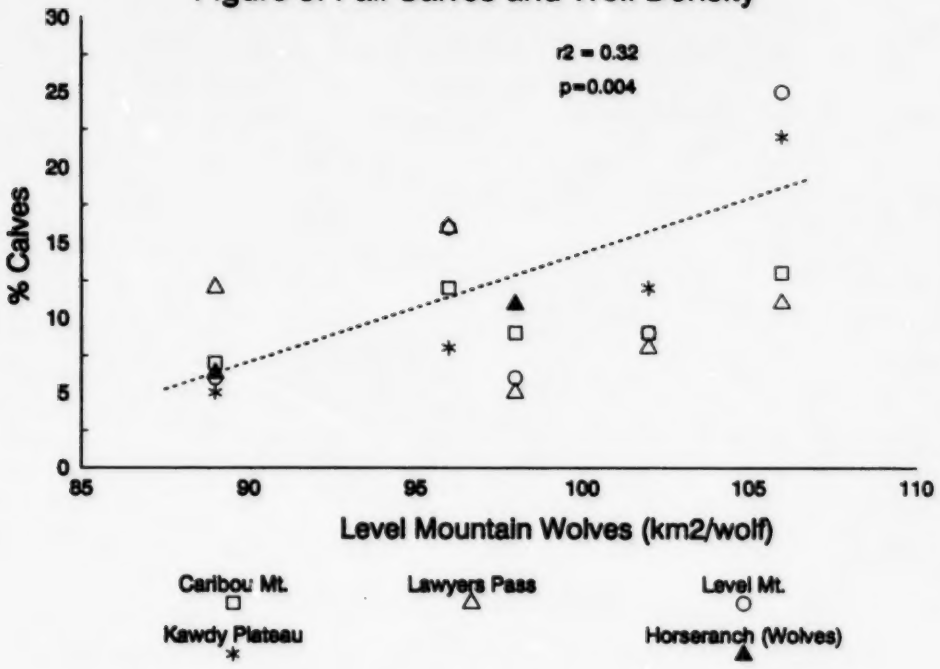


Figure 4. Calves:100 Females and Spring Snow

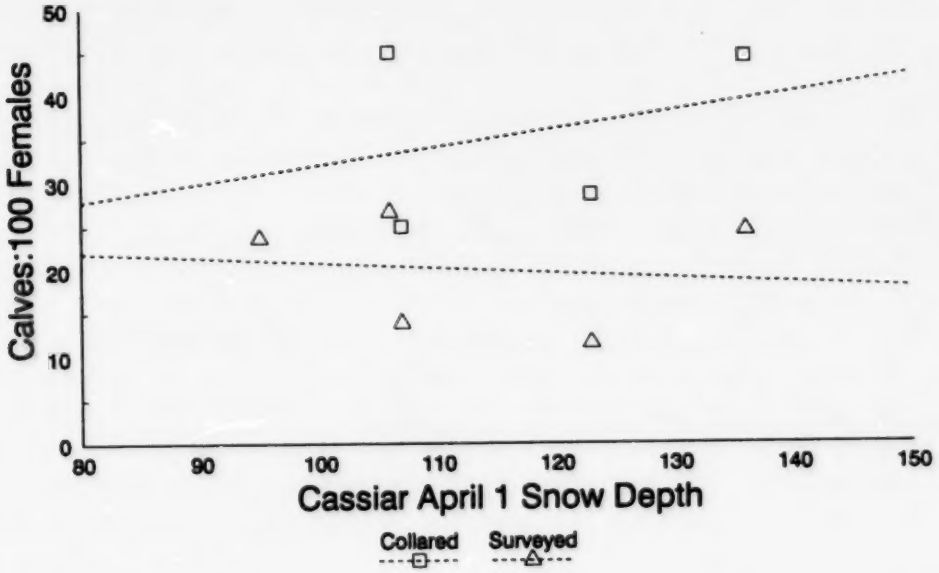
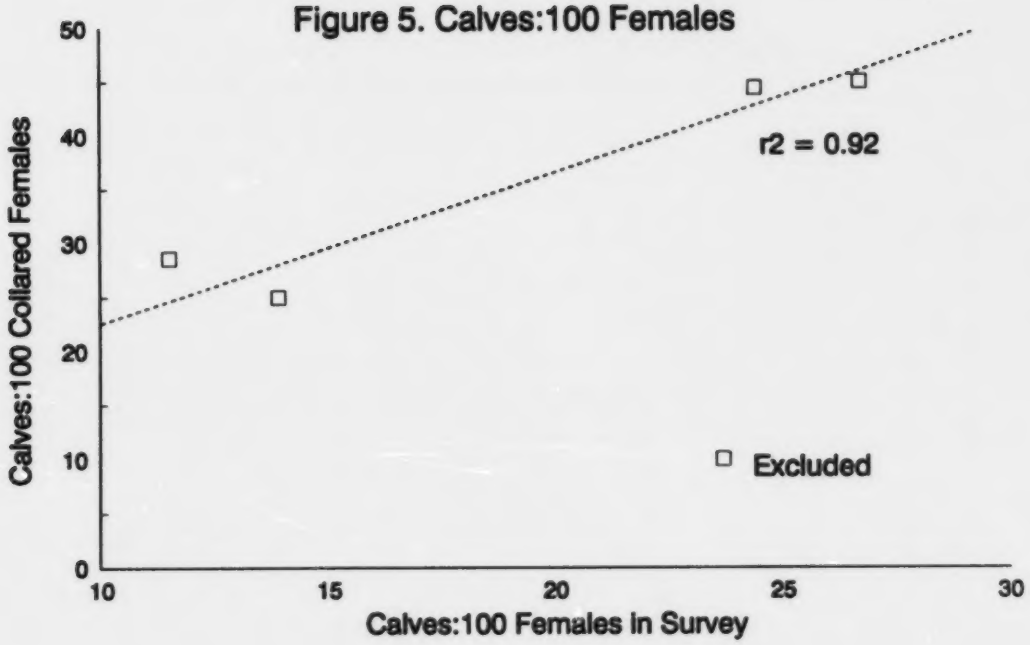


Figure 5. Calves:100 Females



HOW IMPERFECT IS CARIBOU INVENTORY?: A RESPONSE

Ian Hatter, Wildlife Branch, Ministry of Environment, Victoria, B.C.
David Hatler, Spatsizi Association for Biological Research (SABR)

In "How Imperfect is Caribou Inventory?" (these proceedings), R.E. Page re-evaluates the conclusions presented in Hatler (1987. Perspective on Inventory of Caribou in British Columbia. Wildlife Report No. R-14. Ministry of Environment and Parks, Wildlife Branch, Victoria, B.C. 93pp.) and offers a different interpretation of the findings of the Spatsizi caribou inventory research. Since D. Hatler, the principal investigator for SABR was not present at the workshop, and did not have an opportunity to comment, we now wish to respond.

Hatler concluded that rut surveys appear to be of limited usefulness for determining caribou recruitment (whether expressed as calves:100 cows or % calves of total caribou classified). This was based on findings that radio-collared females with calves frequented rut concentration areas (where surveys are conducted) less often than females without calves (see p. 29 of Hatler, 1987). In 4 out of 5 years, the dispersed collared sample showed a higher calf:100 female ratio in the fall than did samples classified in the corresponding rut surveys (p. 32). A biological explanation for these findings was also presented (p. 30). Page dismisses the SABR findings primarily on the basis that the collared sample was not representative, and continues to defend % calves in the fall as a reliable indicator of calf recruitment, or at least, possibly the best that we can get. Our reactions to Page's specific points are as follows:

1) Page argues that % calves is the most reliable population statistic because it does not require complete sightability nor skilled observers. We agree that % calves is less prone to classification error than calves:100 females, since it is often difficult to sex individual caribou in large groups. However, even calf:adult ratios require skilled observers. Given skilled observers, caribou are likely correctly classified when group sizes are not too large. However, this is not the major problem in obtaining an unbiased estimate of calf recruitment. Rather it is timing the surveys in order to count the animals when all sex/age classes are in the same place, or designing surveys that will account for the differential range use and group affinities between classes. It is the representativeness of the survey samples that remains the major concern with caribou inventory in northern British Columbia.
2) Page criticizes calf:female ratios and considers them to be '...a highly variable and unreliable estimator...'. The evidence for this statement

comes from a correlation matrix that indicates % calves among herds are more highly related than calves:100 females. In fact none of the 10 correlations of % calves in his Table 2A are significant at $p \leq 0.05$ and only 2 are significant at $p \leq 0.10$. (Our analysis using the calf percentages in Table 1 indicate that Kawdy and Level Mountain are significantly correlated at $p \leq 0.05$ [$r = .93$] and Level Mountain and Horseranch at $p \leq 0.10$ [$r = .78$]). Page suggests that the problem with calves:100 females is due to adults not being adequately sexed. However, many of the earlier surveys were intended only to collect % calf information, although some females and males were classified on an opportunistic basis (particularly those in smaller groups). The majority of adults in those surveys were, however, unclassified adults. Thus it is not surprising that calves:100 females would be an unreliable index of recruitment, based on these data.

If the analysis is restricted to surveys where all, or most, animals were classified to adult male, adult female, and calf, there is a highly significant correlation (Spatsizi, $r = .872$, df= 6, $p < .005$, Table 2). Thus, we contend that when the appropriate time and effort is taken to classify all animals by helicopter, calf:female ratios are as reliable as % calves, and should be a more useful estimate of recruitment. They may still be biased, however, for the same reasons that % calves can be a biased estimate of recruitment (as described above).

3) Page argues that the "external consistency" of past survey results, in relation to selected external factors, is another indication of the reliability of rut survey data expressed as % calves. Specifically he suggests that fall calf recruitment, previous spring snow conditions and wolf numbers should be correlated such that % calves is lowest when wolf numbers are high and spring snow packs are deep. Deep snow concentrates caribou and makes them more vulnerable to wolves during the calving season (see Bergerud, A.T., and R.E. Page. 1987. Displacement and dispersion of parturient caribou at calving as antipredator tactics. Can. J. Zool. 65: 1597-1606). Page uses % calves from several northern caribou herds, Cassiar April 1 snow depths, and Level Mountain wolf numbers and finds a statistical relationship. Although Page does note that a more elaborate snow index, better and site - specific wolf estimates and data transformations would improve the analysis, he uses this information since he is trying to demonstrate that the % calf index can be used to show a relationship.

Our first concern with his analysis is over the use of April 1 snow depth since it is our observation (Hatler) that this is not necessarily indicative of snow cover at the time of calving. Hatler (1986, Studies of radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia, 1980-84. Wildlife Report No. R-12. Ministry of Environment and Parks, Wildlife Branch, Victoria, B.C. 202pp.) provides contrary evidence to the predation-phenology hypothesis (p. 142-143), and supportive evidence that significant direct weather effects on neonates cannot yet be ruled out in British Columbia.

Our second concern is with the Level Mountain wolf densities. The four wolf surveys were conducted by Hatler (Elliott *et al.* 1984. Northern B.C. wolf-caribou study. B.C. Ministry of Environment, Fish and Wildlife Branch, Victoria, B.C.) with estimates of 49-54+ wolves in 1977-78, 43-44+ in 1978-79, 44-46+ in 1979-80,, and 46-50+ in 1980-81, or a total maximum range of 43 to 54+ wolves and a minimum range of 44-49 wolves. Given the uncertainty in these estimates, and that they are similiar between years, Elliott *et al.* (1984) concluded that the wolf numbers were relatively stable. Certainly these minor fluctuations, even if real, would not be expected to cause large differences in calf percentages, as shown in Fig. 3 of Page. It does also not seem reasonable to correlate calf recruitment throughout northern B.C. with wolf numbers from 7 packs in the Level Mountain vicinity. Such a correlation could only be expected if wolf packs throughout northern B.C. were fluctuating synchronously, prey species composition and abundance and predation rates were similiar, and predation by other carnivores, e.g., grizzly bears, was constant.

4) Page refers to the SABR collared caribou sample as 'incredibly old', states that Hatler had only one female in one instance that gave birth in two consecutive years, and speculates that such old females may not ovulate if they are still lactating in fall, and therefore would not be expected to attend the rutting grounds. In fact, the Spatsizi data indicate than in 111 female caribou years, 90 calves were produced, and for 3 females (aged 3 yrs., 5 yrs., and adult at capture) for which there was 7 years of data (1981-87), 2 had calves every year, and the third had a calf every year except one (Table 3). Further, observations of calving success and calf survival among the collared animals do not support Page's hypothesis that they were generally sporadic or alternate-year breeders. On 16 occasions in which females still with calves in October were also seen at calving the following spring, all but one were known (13) or suspected (2) to have again produced a calf. Included was one female (No. B09) that produced calves in 5 consecutive years (at ages 6-10) and brought them through to

October in at least 3 of those years. No. B19 raised a calf to October in her 13th year, and produced another at age 14. The single failure in the above series was an old female (A04) that successfully raised a calf to October in 1981 (at age 11), but was then barren in the three remaining years of her life.

Information from other studies (see caribou inventory workshop summary) suggests that % calves in the fall may be a reliable estimate of recruitment for some caribou herds. For Spatsizi Park, Hatler (1987) provided statistical evidence that a bias exists. Unfortunately, the magnitude of this bias on recruitment estimates (% calves or calves:100 females) was not quantified, but we believe it could be considerable. The inventory-related studies at Spatsizi suggest that it may be possible to improve surveys in this area, possibly with a stratified random block design in mid to late summer for numbers, and an early winter survey for composition (recruitment, sex ratios). These surveys should be done in order to provide a more definitive evaluation of the present caribou survey methodology in northern B.C.

Table 1. Calf percentages for several caribou herds in northern British Columbia.

YEAR	KAWDY PLATEAU	LAWYERS PASS	LEVEL MT.	HORSE-RANCH	CARIBOU MT.
1976		12			
1977	5	12	6	6	5
1978	22	10	25	17	9
1979	12	8	9	17	7
1980	18	16	16	16	14
1981		5	6	11	9
1982	8	11	1	4	6
1983	15	14		6	15
1984					13

Table 2. Relationship between % calves and calves:100 cows on the three caribou rutting areas (from Hatler 1987).

YEAR	% CALVES	CALVES: 100 COWS	AREA	% CLASSIFIED
10/79	11	17	C,T	100
10/79	7	9	C	100
10/81	8	17	C,T,E	100
10/82	10	14	C,T,E	100
10/83	15	24	C,E	100
10/84	13	27	C,T,E	100
10/85	12	21	C,T	100
10/86	15	24	C,T,E	94

Table 3. Calf status per female, Spatsizi Park

Animal	Age[a]	1981	1982	1983	1984	1985[b]	1986	1987[b]	Total Calves	No. of Years
A00	5	S[c]	C[d]	C[e]	C[e]	C[e]	C[e]	C[e]	7	7
A01	2	C[f]							1	1
A02	3	S[f]	S[c]	S[c]	C[e]	C[e]	C[e]	C[e]	7	7
A03	YA	S[f]							1	1
A04	10	C[d]	W[g]	B[h]	B				1	4
A07	AA	C[d]							1	1
A08	8	C[e]	S[c]	C[e]	C[e]	C[e]	B	C[e]	6	7
B02	12+			C[e]					1	1
B03	2			W	C[d]	C[e]			2	3
B04	YA			C[e]		B	C[e]		2	3
B07	AA			C[e]	C[d]				2	2
B08	YA			S[f]	C[e]	C[e]	C[d]	S[f]	5	5
B09	S+			C[d]	C[d]	C[e]	C[d]	S[f]	5	5
B10	AA			C[e]	B	U[i]	B		1	4
B11	YA			C[e]	B	C[e]	C[d]	C[e]	4	5
B12	16			B					0	1
B13	12			C[e]					1	1
B14	AA			C[e]	W	W?	C[e]		2	4
B15	?			C[e]	S[c]	C[e]	C[e]	C[e]	5	5
B17	1			B					0	1
B18	9			S[c]	U	S[f]	C[d]		3	4
B19	11			S[c]	C[d]	C[e]	B		3	4
B20	10			C[e]	C[d]				2	2
B21	3			C[e]	U	C[e]	C[e]		3	4
B23	AA			C[d]					1	1
B24	YA			W	C[d]	C[e]	C[d]	C[e]	4	5
C38	YA			B	W	C[e]			1	3
D40	AA				C[d]	C[e]	C[e]	C[e]	4	4
D41	YA				C[d]	C[e]	C[d]		3	3
D42	AA(old)				C[d]	C[e]	C[d]	C[e]	4	4
E43	AA					C[e]	C[d]	C[e]	3	3
E44	AA					U[i]	C[j]		1	2
E45	YA					S[f]	C[d]		2	2
F46	YA						C[e]	C[e]	2	2
TOTAL									90	111

[a] age at capture: AA = Adults, believed at least 4-years-old by tooth wear and other characteristics; YA = young adults, believed 2- to 3-years old.
[b] no data in fall; [c] female seen without calf in October; [d] calf seen in October or later; [e] known to have had a calf in June; [f] suspected to have had a calf in June; [g] without calf, suspected barren; [h] known barren; [i] unknown (not seen in June).

Reply to Hatter and Hatler
from a letter to Hatter 19 September 1989

...I am willing to let the readers judge between my opinion and Dave Hatler's, which will clearly continue to differ. I would like to reiterate my only point - that despite the inevitable presence of sampling error and bias, recruitment determined from fall rut surveys remains the most valuable and easily collected inventory statistic for northern caribou herds.

Dr. Richard Page, PhD, RPBio
Wildlife Habitat Analyst
Research Branch
Ministry of Forests
Victoria, B.C.

RESEARCH AND DEVELOPMENT PRIORITIES FOR CARIBOU MANAGEMENT IN BRITISH COLUMBIA

- a discussion paper -

D.S. Eastman, R. Page and G. Jones

1.0 INTRODUCTION

The purpose of this paper is to propose a research strategy that supports the management and conservation of caribou in British Columbia. Currently, caribou management is a controversial issue. For example, habitat protection guidelines have adverse impacts on timber supply; the rapid expansion of forestry activities has had adverse impacts on caribou and their habitat; and the relative significance of predation versus habitat change on caribou populations is unclear. These concerns are interagency in nature, having major implications and consequences to the management of both caribou and timber. Since the issue is due partly to inadequate information, research is needed to fill gaps and so contribute to resolution of the issue, as well as to increase public support for the conservation of caribou.

The current high level of investment in caribou research reflects the degree of management concern and lack of information. At least four studies are in progress, a fifth is planned, and three are just ending. As well, B.C. caribou were the subject of two major reviews (Bergerud 1978, Stevenson and Hatler 1985) and a workshop (Page [ed.] 1988) that has resulted in almost 900 pages of text. In fact, the proliferation of projects has raised additional concerns about their degree of overlap, and their efficiency in answering the key questions faced by resource managers.

We considered research needs in relation to issues identified by management agencies. Thus, we focussed on applied or mission-oriented research. The needs of management were identified by consideration of the two provincial reviews and the workshop proceedings, since they synthesized so much relevant background information; by the review of current drafts of regional and provincial wildlife plans; and through discussion with resource managers. Management concerns primarily reflect those of the three government agencies principally involved with caribou: the Wildlife Branch of the Ministry of Environment, Ministry of Parks, and the B.C. Forest Service.

1.1 Some relevant features of caribou ecology

Some problems in managing forests and caribou result partly from failure to recognize geographic differences in caribou ecology. We list below some key considerations that should be remembered in arriving at research needs:

- Two ecotypes: With respect to winter habitat requirements, two ecological patterns are evident: in high snowfall areas, caribou feed primarily on arboreal lichens, while in low snowfall areas they feed primarily on terrestrial lichens. Thus the habitats used by caribou and the impact of timber management activities on them varies according to these two patterns. The current labels of mountain and northern types are misleading since many northern caribou live in mountains and some feed on arboreal lichens. We propose that caribou be classified as living in low snowfall areas or high snowfall areas, and that these zones be tied to an ecological classification system such as the Wildlife Ecosystem approach developed by D.A. Demarchi, Wildlife Branch, B.C. Ministry of Environment. Generally, the arboreal lichen caribou are found in the southern Rocky Mountain area, and the terrestrial feeding caribou occur west and north of this region.

- Widespread: caribou occur throughout B.C. in many habitats except for grasslands and coastal forests. The extinct Dawson caribou lived in the maritime forests of the Queen Charlotte Islands and historically, caribou occurred in the dry forests of the Okanagan. Thus they are an adaptable species with respect to habitat, but, this does not deny the importance of critical or key habitats.

- Diverse diet: Caribou eat a wide variety of vascular and non-vascular plants at all times of the year, dependent on availability. However, caribou's dependence on lichens in winter, makes them sensitive to factors that could modify the supply of lichens, especially the arboreal lichen feeders.

- Mortality-driven: mortality factors are the prime determinants of population performance. Caribou have a relatively fixed reproductive rate across their circumboreal range: single calves only, born annually. Age-specific reproductive rates are relatively constant once sexual maturity is reached at two years; calving rates of young females are low. Consequently, increased forage supplies will probably not result in a reproductive response and perhaps not in increased survival. Research in B.C. and elsewhere has demonstrated that neonatal mortality and recruitment to age 1 are key variables. Predation is a significant cause of this mortality, but the accidental loss rate can be high, up to 30% (Page 1985). The importance of weather as a mortality factor at calving remains in dispute for some biologists.

- Gregarious: caribou are preferentially gregarious, although group sizes increase with the openness of the habitat. This type of sociability increases their vulnerability to illegal hunting.

- Unpredictable migrators: seasonal ranges and migration routes appear more traditional and therefore predictable for northern caribou than southern herds. Consequently, key habitats and access problem areas are generally easier to define and manage for northern caribou than for southern ones.

- Vulnerable to overhunting: caribou appear curious and "unafraid" of people, thus making them particularly vulnerable to overhunting and poaching, especially in accessible areas.

1.2 Management Objectives and Concerns

1.2.1 B.C. Wildlife Program

The Wildlife Program of the Ministry of Environment is responsible for caribou management in the Province except in Provincial and National Parks. The Program has two major goals: to maintain species' presence in major biophysical zones, and to provide for sustained use. Specific to caribou, the objectives are:

(a) to have a population of at least 20,000 distributed on traditional ranges throughout B.C.;
(b) to provide opportunities for viewing in natural habitats; and
(c) to provide an annual sustained kill of 1,000, with 20,000 hunter-days of recreation.

These provincial expectations are subdivided into regional components.

With respect to the first objective, the 1987 estimated population of caribou in the province was 13 000. Assuming that this is a pre-calving estimate, then current numbers are 65% of the stated objective. Based on forecasts in the Regional Wildlife Plans, the target of 20 000 animals will not be reached within the five-year planning period and projections beyond this period are not optimistic. The likelihood of maintaining the distribution of caribou in traditional ranges has not been explicitly treated.

With respect to the second objective, it seems likely that some progress will be made towards it, given the growing emphasis on appreciative uses of wildlife in the Wildlife Program. Whether or not this objective will be attained is difficult to judge except qualitatively, given its subjective wording.

The third objective will likely not be met, based on information in the regional plans. Regional populations are not projected to increase sufficiently over the next five years to provide the desired harvest and number of recreational hunting days.

In summary, the wildlife and habitat managers are faced with the challenge of what they can do to meet their management objectives. The first step is to examine the key issues that currently impede the opportunities for meeting objectives. These issues are described in regional and provincial wildlife plans.

Three major and several minor issues concern regional wildlife and habitat managers (Tables 1 and 2). The first and most important is the impact of habitat change on caribou, especially due to forestry activities on winter ranges. Second, managers are concerned about the impact of mortality factors other than hunting, especially predation and poaching. The third major issue is lack of affordable and reliable methods of census, particularly for the southern herds. Other important issues are impacts of access, mining, and losses due to collisions, but the three principal issues are the impacts of habitat change, the significance of predation-related mortality, and inventory methods.

1.2.2 Forest Service and Industry Concerns

Industry's major concern is that if large quantities of valuable timber become reserves for caribou habitat then forest management objectives will not be met. Consequently, logging companies have stated a preference for extended rotations rather than reserves. However, preliminary analyses indicate that the caribou habitat provided by a 200-year rotation (which would reduce the Annual Allowable Cut by 40%) could be achieved with only 20% of the land in reserves.

Concern has also been expressed about the impossible task of achieving integrated resource management "everywhere" or on a hectare-by-hectare basis. For example, it would be preferable to "zone" one area for timber production and another for caribou production. A related concern is that industry questions the reservation of timber that has little or no documented value to caribou population objectives.

The Forest Service echoes industry concerns and is worried about the immediate loss to the Annual Allowable Cut of large (though perhaps temporary) reserves and deferrals. Also the current system of forest planning referrals leads to unacceptably long delays and conflicts.

All forestry organizations support the maintenance of critical caribou habitats and old-growth reserves if necessary, but other solutions and creation of caribou habitat in silviculturally manipulated stands is preferred. Cavill (1988) encouraged wildlife, habitat and forestry managers to explore options for integrated management of timber and caribou.

1.2.3 Ministry of Parks Concerns

The Ministry of Parks is responsible for management of caribou within Provincial Parks and Recreation Areas. The objectives of caribou management within parks are to protect the populations, and to provide consumptive and appreciative uses of caribou. Several park caribou populations such as those in Spatsizi, Tweedsmuir, and Wells Gray are provincially significant, and therefore the Ministry of Parks plays a key role in provincial caribou management. Most park caribou populations use habitats within and adjacent to the parks, and consequently management within parks is closely coordinated with the Wildlife Program.

The most important concern of the Ministry is to ensure that park caribou populations are maintained. Since inventory is essential to monitor the status of the populations, it is a priority to collect this information and to support research that improves the reliability of caribou census methods.

Several park caribou populations use winter ranges that are outside of the parks. These ranges could be impacted by logging and other resource developments; therefore it is important to determine how these activities should be managed to protect essential habitats. The Ministry has already cooperated with the Wildlife Program and the Ministry of Forests to study the interactions of caribou and logging in several areas.

The role of predators in caribou ecology is of interest since parks preserve examples of predator-prey systems. Thus, continuing studies are needed on the relationships between predators and caribou to provide information for protecting both the caribou and the predators. The current Parks policy is to encourage studies of predator-prey systems, but to disallow studies requiring experimental predator removals. However, parks can be suitable as non-removal areas for comparison with removal areas.

Several parks contain important habitats, such as winter ranges, that must be protected to ensure the maintenance of caribou. Since Parks' habitat inventory information is incomplete, a need exists to improve the methods of classifying caribou habitat, and also to continue to inventory those habitats.

Wildfire management is a major issue in many parks, and the role of fire in the ecology of caribou habitat is unclear. Therefore, it is also important to improve our understanding of how wildfires should be managed to ensure the long-term maintenance of caribou habitats.

All parks are used and managed for human recreation, and it is essential to know how to manage recreation to avoid undesirable influences on the caribou. It is particularly important to determine how hunting should be managed to maintain the populations and how harassment from winter sports such as heli-skiing and snowmobiling can be managed so that caribou are able to use critical habitats.

2.0 CURRENT CARIBOU RESEARCH

2.1 Current management needs

Based on the previous section, the most important management questions can be summarized as follows:

(1) What methods need to be developed or improved to classify, map and evaluate caribou habitat so that resource managers can manage caribou habitats to incorporate activities such as forestry while providing for features needed by the caribou?

(2) How can we diagnose and assess the effects of predation on caribou, and how can we manage the predator-prey system to maintain desired populations of both caribou and their predators?

(3) How can methods to monitor the status and trends in population size and demographics of caribou be improved?

(4) How can harrassment be assessed and managed to minimize its effects on caribou?

(5) How should wildfires be managed to ensure maintenance of caribou habitat?

2.2 Relevance of current research to management needs

2.2.1 Habitat classification, mapping, evaluation and management

All caribou research projects have classfied habitats as part of their project design, though the level of detail and classification system has varied. For example, Seip (1988) used broad groupings of forest cover types derived from Ministry of Forest forest cover inventory maps. Hatler (1988) used descriptive habitat classes such

as coniferous forest and alpine that can be related to existing forest cover type maps or ecological maps only with additional work. Antifeau (1987) and Simpson *et al.* (1987) used forest zones or biogeoclimatic zones. Cichowski (1988/89) and Fenger *et al.* (1986) used ecologically based maps although based on slightly different classification systems.

A major problem with these habitat classification and mapping activities is that they have produced results that are not all easily relatable to classification systems used by foresters and other land managers. This incompatability creates difficulties in translating caribou habitat needs into a language (a communication barrier) and onto maps used by foresters in their routine forest management activities (a planning barrier).

A second problem deals with building the information base on seasonal habitat use by caribou. Unless a habitat map is prepared before conducting observation of caribou, it is usually difficult to reliably relate observation to habitat units, especially if maps of habitats and survey flight lines are at different scales (Fenger 1988). Moreover, if observations of caribou seen on aerial surveys are not described in appropriate habitat terms, much potentially useful data are lost.

None of the current projects looks at caribou habitat potentials in managed stands. Part of the problem is that so few caribou occur in managed stands that key habitat attributes can be identified only by inference from caribou use of unmanaged stands. The current Yellowhead study is partly aimed at this topic by proposing to treat stands to match characteristics of winter habitat, as they are presently understood (K. Child, pers. comm.). This approach will be expanded to other parts of southeastern B.C. Since arboreal lichen production responds to treatments very slowly, a long-term approach must be taken.

2.2.2 Predation

Predation has been addressed in all current projects, though to varying levels of detail. The most common information has been gathered from mortalities of radio-collared animals, and from survey flights that document changes in proportions of calves.

In most of these projects, predation has been implicated as a major mortality factor. Using mortality sensing collars on calves in northwestern B.C., Page (1985) documented 80% and 50% losses of caribou calves to four months in 1979 (n=11) and 1980 (n=23), respectively. He concluded that predation by wolves and grizzlies were the principal reasons for these losses, although 25%(5) of the deaths were by accidents. Bergerud and Elliott (1986) concluded that wolf predation was the main factor causing

population declines in some northern herds, based on work by Page (1985), and experimental removal of wolves (Elliott *et al.* 1984) and standard inventories of caribou. In a preliminary report of an east-central B.C. study, Seip (1988) found very low survival of calves over the summer when wolves were present, and that wolf predation and accidents were important adult mortality factors (a total of 23 adult cows were collared in 1984 and 1985). In a study of two caribou herds in west-central B.C., Cichowski (1989) determined causes of death of 10 of 21 mortalities of radio-collared adults. Of these 10, eight were predation-related at least seven of which were by wolves. Calf survival in the Itcha-Ilgachuz-Rainbow herd declined over the three years of study, and in the Tweedsmuir-Entiako herd, calves of radio- collared cows was 0%, 0% and 10% on the three years.

2.2.3 Improving inventory methods

This topic was specifically addressed by Hatler (1987) who provided many suggestions and ideas on census methods, especially for northern B.C. caribou. He concluded that fall surveys are of limited usefulness in determining population status, that winter surveys for arboreal feeding caribou are useful if they can be timed appropriately, and that summer surveys have potential because summer is the period when caribou most consistently occur above treeline.

Inventory methods were tested briefly in the West-Central project, but results are not written up at this time (D. Hebert, pers. comm.). Simpson and Woods (1987) estimated caribou numbers based on mark-recapture ratios but the proportion of marked animals was probably too small for the population being estimated. These authors also recognized problems in counting caribou.

Other current and historic caribou projects did not address inventory needs specifically and consequently provide little insight into ways of improving census methods. However, Hatter (1988) provided useful suggestions for estimating sample sizes for recruitment, population trend and total numbers in caribou.

2.2.4 Harassment

Apparently, only one B.C. project has addressed explicitly the response of caribou to harassment . Working on arboreal-feeding caribou near Revelstoke, Simpson (1987) found that human scent and large groups of snowmobiles reduced caribou use of winter range. Based on caribou's ability to habituate to some disturbance, he recommended guidelines regarding locations and levels of use for snowmobilers that should be tested on a trial basis before more permanent adoption. Simpson (1987) also suggested that snowmobiling should be re-directed to areas not used by caribou.

The response of caribou in northern B.C. (primarily terrestrial lichen feeders) to harassment has not been documented. However, as this topic has been studied for Arctic caribou, some of these results may be applicable to this province.

2.2.5 Managing wildfire

No current research addresses this need directly, but there is a great deal of literature that should be reviewed before anything is done.

3.0 FUTURE RESEARCH AND DEVELOPMENT - NEEDS AND APPROACHES

3.1 Introduction

Stevenson and Hatler (1985, 1988) provided the most complete set of research recommendations for central and southern caribou. They identified the following research topics as high priority, based on a thorough review of available data, the literature and experience:

- evaluation of energetic needs of caribou on an annual basis;
- the role of predation in regulating caribou numbers; and
- reliable census methods to estimate numbers and herd composition.

A variety of other topics were judged to be of low or moderate priority, but these research topics correlate strongly with current management concerns.

These authors also recognized the high degree of interaction and inter-relationship between identified research topics, and so they posed broad questions that could be the focus of study. One focus is separating the impact of habitat changes from that due to associated access development. This topic relies upon a second topic, an understanding of habitat selection patterns of caribou and their ecotypic variations. The second question is primarily one of assessing how caribou respond to major changes in their environment, habitat quantity and quality, e.g., in numbers and animal conditions (changes in range occupancy could be added to this list of response variables). The third topic interacts with the first two. Other than telemetry data, the strongest evidence for a predation problem is survey data indicating recruitment factors. Bergerud has suggested that logging reduces caribou numbers by increasing vulnerability to predation and by causing shifts in habitat use.

Two other topics, optimal design of habitat reserves and transplant technology, could be addressed as add-ons to other topics or as a synthesis of current studies on caribou.

3.2 Inventory methods

The need to improve or change existing inventory methods was expressed strongly both in regional wildlife plans and by Stevenson and Hatler (1985). The major areas of concern appear to be:

(a) lack of comparability over time and between areas, i.e.,standardizing methods;
(b) degree of bias in estimating population structure;
(c) precision and bias in estimating population size; and
(d) excessive cost.

This problematic question can be re-phrased as how much of a change, with what reliability, must be detected before management decisions change? We need to examine benefits of the extremely costly alternatives before deciding that current approaches are inadequate. Perhaps cheap methods will not be possible and we should stop asking a question that is too expensive to answer.

Stevenson and Hatler (1985) criticized past census methods, and Hatler (1986) provided a solid data-base and suggestion for future approaches. Hatter (1988), offered other approaches to inventory that should be examined. For example, we could adapt the Yukon approach by conducting highly reliable censuses on key or representative herds and either foregoing inventory or doing reconnaissance level surveys elsewhere (R. Farnell, pers. comm.). On these intensive survey sites, stratified block methods could be tested and evaluated, coupled with radio-collared caribou to evaluate sightability and other biases.

Another approach would be periodic inventories, say at 5-10 year intervals. Alternatively, a less intensive survey could focus on a specific management question, ie.,does recruitment exceed 12%? or has the population increased?

For the future we offer the following suggestion:

(a) develop acceptable methodologies appropriate to management priorities, including definition of management units, benefit-cost analysis and required levels of reliability;

(b) develop a province-wide inventory program that includes standardized data recording, entry and storage systems, building upon the current Ungulate Inventory Data-Base; and

(c) incorporate testing of inventory methods into current and new caribou research projects and, where possible, apply sample-based approaches in routine management surveys.

3.3 Mortality factors

The second major need concerned population dynamics. Given the species biology, this concern should focus on rates and causes of mortality in neonates and in adults, with special attention to predation. Compared to 10 years ago, the role of predation is now seen as a principal factor in controlling woodland caribou. This acceptance is due largely to the research conducted since that time, both in B.C. and elsewhere in North America. Although the role of predation is "accepted" now, managers have mixed views on applying this knowledge, and both researchers and managers have unanswered questions that require investigation. Some of the key topics include:

(a) causes of neonatal mortality. Evidence points to losses of up to 60% in the first month of life, but few carcasses have been found and of these, few have been examined, in sufficient detail to identify cause of death. The role of weather requires clarification;

(b) causes of mortality from 1-12 months. Again, evidence points to often significant losses, with wolves and bears implicated in both southern and northern herds. The onus should now be on researchers to determine when and if predation is <u>not</u> the cause of calf mortality, since it has been the major factor in every intensive study;

(c) interactions in multiple species systems. A key question here is the role of moose in modifying wolf predation on caribou, i.e., if an area is logged and favors an increase in moose, then possibly wolves will increase in response to this and be able to reduce caribou numbers by switching as they increase in abundance. Also of concern is the role of grizzly bears and other mammalian predators; and

(d) interactions between habitat and predation. This topic includes the "lost in space" concept of Bergerud *et al.* (1984), and also the system changes resulting from habitat modification, ie., increased encounter rates with predators if animals are confined to "critical" habitat refuges.

The research need goes beyond the identification of mortality factors: it includes the development and evaluation of techniques to identify when predation is a serious factor, and the development of practical and effective predator and habitat management strategies.

3.4 Impact of habitat changes

The third research topic relates to habitat selection. We now are at a point where existing studies need to be synthesized and summarized. We believe these short-term, small sample studies will show strong similarities in the functional behaviour of caribou in selecting habitats, and provide the basis for a predictive model useful to managers. Also, we believe this exercise will identify the following issues for future research and development:

(a) a functional description of caribou habitats;

(b) an evaluation of which habitat(s) are most critical and why, probably based on a bioenergetic approach;

(c) the previous topic of relating habitat change to predation pressure and caribou; and

(d) developing enhancement techniques for terrestrial and arboreal lichen and alternate foods. Clearly, this work will apply most to the areas of the province where significant forestry occurs or will occur. Its significance may increase as key winter ranges become restricted due to development.

4.0 OTHER SUGGESTIONS

Despite the flurry of caribou research projects in the province, we sense that managers have not adopted the management implications of research results. In other words, the critical transfer of knowledge is incomplete. A variety of reasons account for this situation, including a lack of provincial direction and policy on caribou management, resistance of other resource managers, a lack of sufficient and appropriate training, and a concern over the technical adequacy of research (samples too small, locations too infrequent, etc.). These difficulties must be addressed before caribou management advances.

4.1 The need for a provincial management strategy

An overall provincial approach is needed to set direction and allocate resources. Stevenson and Hatler (1985, 1988) suggested one approach and provided recommendations for a provincial management strategy for caribou. Their suggestions arose from their study of southern B.C., but can be generalized to the whole province. Briefly, they recommended:

- stratify caribou ranges into high, medium and low priorities for management;

- use biogeographical principles in ranking and designating the herds within these areas; and
- develop management strategies for each priority class, with more conservative or restrictive strategies for higher priority ranges.

At this time, none of the responsible management agencies have formally adopted, modified or rejected these principles, although Halladay (1988) expressed reservations. The resulting vacuum has perpetuated conflicts, especially in southern B.C., facilitated proliferation of many caribou projects, and hampered development of a provincially-based research program. It is important that we have a provincial caribou management strategy to guide further research and management activities.

5.0 FUTURE ACTIVITIES PROPOSED FOR CARIBOU MANAGEMENT

- Synthesize results and understanding from current B.C. studies on caribou and describe their relevance to population and habitat management.
- Prepare four management products, once sufficient research findings and other pertinent information are on hand:

  (a) a caribou inventory strategy;
  (b) inventory guidelines;
  (c) guidelines for managing caribou habitat; and
  (d) strategy for classifying, protecting and managing caribou habitat.

- Complete a provincial caribou management plan that addresses regional concerns such as access and wildfire, and evaluates the proposals of Stevenson and Hatler (1985, 1988).

- Establish a caribou management steering committee with at least the following technical subcommittees:

  (a) Research
  (b) Communications
  (c) Integrated forestry/caribou management.

- Support one multiple species predator-prey study. The low snowfall ecotype may be most appropriate due to the greater density of animals.

- Support at least one habitat manipulation study for the high snowfall ecotype, that include enhancement of arboreal forage after logging.

- Conduct research into methods of determining biologically significant caribou management units, including the optimum design of habitat reserves.

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Appendix A: Status of current research as of 1989 February.

Ten Projects are summarized briefly here on a geographic basis; from south to north:

(a) Selkirk (Servheen and Lyon 1989; Rominger and Oldenmeyer 1989): seasonal habitat use, distribution and limiting factors of a remnant caribou herd; telemetry studies of 6 native animals plus about 30 from 2 transplants; intensive study involving ground observations and forage carrying capacity determination of the native herd.

(b) Revelstoke (Simpson *et al.* 1987): field work from 1982-1985; documented home ranges, seasonal habitat use, seasonal diets and population characteristics; data based mainly on 1-6 functioning collars, supplemented by aerial and ground observations of other caribou.

(c) North Thompson (Antifeau 1987): winter ecology; based on about 2 years of telemetric data on four adults (3 females, 1 male) obtained by periodic fixed-wing surveys, plus ground studies on snow and lichen abundance; the study documented home range sizes, and semi-annual shifts in elevation.

(d) Wells Gray (Seip 1988): seasonal habitat use of caribou; begun in 1986 and ending in 1989; based on approximately bi-weekly locations of about 25 from fixed-wing aircraft plus helicopter surveys three times/year; two wolves collared;

(e) Quesnel Highlands (Seip 1988): begun in 1985; field work has ended; study examined production and survival of calves under different levels of wolf densities and seasonal habitat use patterns; based on weekly locations of 23 radio-collared caribou, from fixed-wing aircraft, plus helicopter surveys in June; four wolves radio-collared.

(f) West-central B.C. (Cichowski 1988/89): telemetry-based study to determine seasonal ranges of caribou in an area where proposed logging overlaps winter ranges; initially. Radio-collared adults were monitored by fixed-wing aircraft on regular basis, except opportunistically in the Tweedsmuir-Entiako area. In 1985, a second project began in the Itcha/Ilgachuz and Rainbow Mountains using 27 radio-collared caribou. These two studies were combined due to their geographical proximity. Field work has ended, and results are being written up as a M.Sc. thesis by Debbie Cichowski, a graduate student in Forestry, Univ. British Columbia.

(g) SE British Columbia (K. Child, pers. comm.): a series of inter-related projects, 2 of which are located east of Prince George. One is a habitat capability mapping project and the other is a radio-telemetry study of caribou in heavily logged and lightly logged areas. The third component is to set up trial and demonstration areas throughout SE B.C. that explore ways to using silvicultural techniques to create caribou winter habitat. The fourth component is developing habitat management strategies for caribou.

(h) Spatsizi Park (Hatler 1986): the longest running caribou study in the province; data collected by periodic, usually monthly, fixed-wing surveys of 15-20 radio-collared adults, supplemented by periodic helicopter surveys during calving in the fall.

(i) Spatsizi Park/Level Mountain (Page 1985): a study of calf survival based on 23 radio-collared neonates on two areas, and documenting their mortality until October.

(j) Level Mountain/Horseranch Range (Elliott *et al.* 1984): a comparison of calf survival in two caribou herds; wolves on one area were reduced to low densities and calf survival was compared to another herd on Level Mountain where wolves were not controlled; no radio- telemetry.

Table 1. Generalized concerns for caribou management expressed by Ministry of Environment wildlife and habitat managers.

Region	Management concerns
Okanagan	Unmanaged access, loss of early winter habitats
Kamloops	Loss of winter habitats; mortality through poaching and potentially predators
Cariboo	Regulating access; loss of fall/early winter habitats, especially east of Fraser River; potential increase in wolf predation and timber harvest in western area; lack of suitable census methods
Omineca	Lack of inventory techniques; impact of forest harvesting on traditional (winter) key habitats; potential impacts of collisions, predation and poaching on mortality
Peace	Inadequate inventory methods; potential impact of predation and habitat change through increased logging

Table 2. Regional research needs primarily as listed as "additional activities" in Regional Wildlife Plans.

Individually mentioned topics	Regions requiring research									No.of Mentions
	Okan	Kam	E.Koot.	W.Koot.	Cariboo	Skeena	Omineca	Peace	Liard	
1. Transplant techniques					X*		X			2
2. Seasonal habitat use and needs	X*	X*			X	X*	X	X		6
3. Census techniques	X*				X	X*	X	X		5
4. Role of predation					X					1
5. Calf mortality causes					X			X		2
6. Adult mortality rates					X				X*	2
7. Migration patterns					X		X*			2
8. Diet					X					1
9. Condition					X					1
10. Arboreal lichen loads					X					1
11. Collision							X*			1
12. Pop. dynamics (simulation)							X			1
13. Wolf research		X*			X		X			3
14. Large mammal pred./prey						X				1
15. Terrestrial lichen ecology						X*				1
16. Grizzly and caribou		X*					X*			2

* inferred need

Amalgamated topics

1. Inventory methods (3)	X				X	X	X	X		5
2. Population dynamics (4,5,6,12,13,14,16) (includes predation, mortality)		X			X	X	X	X	X	6
3. Habitat selection/migration (7,8,9)	X	X			X	X	X	X		6
4. Habitat enhancement techniques (10,15)					X	X				2
5. Transplant techniques					X		X			2
6. Collision							X			1

APPENDIX

Province of British Columbia Ministry of the Environment 73 MEMORANDUM

To: Caribou Workshop Participants

Date: Oct. 14, 1987
File: 40.4906

Re: Caribou Workshop

There has been general agreement that a caribou workshop is a necessary prerequisite to T.S.A. planning and to future inventory and research.

It has been decided that November 24-25-26 are suitable dates and that the meeting will be held in Williams Lake in the government building (room to be decided).

The actual working group will be kept to less than 25 in order to fully discuss the following agenda:

Nov. 24 - SOUTH EASTERN CARIBOU BIOLOGY (D. Hebert) (8:30 a.m.)

A. LICHEN ECOLOGY (EARLY AND LATE WINTER RANGE MAINLY)
- distribution, growth, yield, availability, utilization, intake, carrying capacity, range, variation, etc.
S. Stevenson, E. Rominger (2 hr) (1 hr open discussion)

B. CARIBOU BIOLOGY
- Seasonal description, habitat components, herd variation, effect of disturbance and access, limiting factors - predation, habitat.
D. Seip, T. Bergerud

WORKSHOP DISCUSSION - INTEGRATION OF TOPICS A & B
(Continued in evening if necessary)

Nov. 25 - INVENTORY AND POPULATION DYNAMICS (I.Hatter)

1. Present status of caribou inventory in B.C. (I. Hatter - 1/2 hour).
2. Limitations of caribou survey methodology in Northern B.C. (D. Hatler - 1 hour)
3. Sample based survey designs for caribou
(R. Farnell Yukon - 1 hour) Strat. random block
(T. Smith - D. Cichowski (1/2 hour) Mark recapture
4. Classification criteria for caribou
(G. Jones (1/2 hour)
5. Managing caribou populations with imperfect information
(R. Page - 1/2 hour)
6. Workshop Discussion
Caribou population monitoring - 2 hours

EVENING - HISTORY OF CARIBOU BIOLOGY MANAGEMENT IN SOUTH-EASTERN B.C. (R. Ritcey - Tentative)

M-388

Nov. 26 RESEARCH REQUIREMENTS AND DIRECTION (R. Ritcey)
(Morn)

Non B.C. Government

T. Bergerud
D. Hatler
S. Stevenson
E. Rominger
G. Servheen
D. Seip
K. Simpson
D. Cichowski
T. Antifeau
F. Bunnell

B.C. Government

R. Ritcey
D. Hebert
M. Beets
J. Elliott
D. Eastman
R. Page
G. Jones
D. Hamilton
D. King
T. Smith
G. Woods
R. Marshall
D. Steventon
K. Child
J. Young
H. Armleder
C. Spence

The workshop will attempt to discuss, summarize and standardize our information and direction in the management of the south eastern caribou herds. I hope to complete this part of the discussion with a concise management strategy for these herds. The immediate needs involve our management procedures and TSA programs.

The discussion of inventory will be organized and chaired by I. Hatter. It will attempt to outline inventory procedures and problems for northern and southern herds, in order to develop an understanding of population dynamics and harvest management.

The research portion will outline the provincial priority and needs for caribou research and research specific to individual herds (predator-prey).

Additional participants (Ministry of Forests, industry) will be limited (B.C. Wildlife Federation) in order to promote maximum discussion.

Rooms can be booked at the Overlander, Fraser Inn, Travelodge, etc. If you would like me to book your room, please let me know.

D Hebert

Dr. D. Hebert
Head Wildlife Biologist
Cariboo office
Southern In erior Region

DH/bm